July 1969

Railway Signaling & Communications

Our only quota is quality.

A cross section of cable shows you only two dimensions of what you buy.

The third dimension of a cable, which is its consistency of quality, must be known before you can appraise its performance. The quality of a cable is no greater than the strength of its weakest point. Kerite cable also gives you the fourth dimension of time.

The Kerite Company · Principal Offices: New York, Chicago, Seymour, Connecticut · Sales Representation Throughout the United States.

MEMBER RPI Kerite

the cable that lasts... and lasts... and lasts...

Simmons-Boardman TIME-SAVER Publication

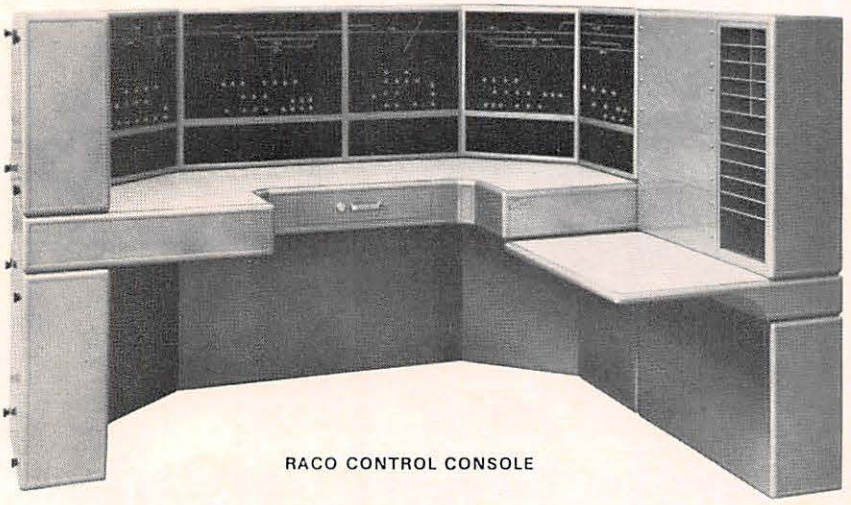
RACO®

CONTROL PANELS "TAILORED" TO YOUR EXACT NEEDS

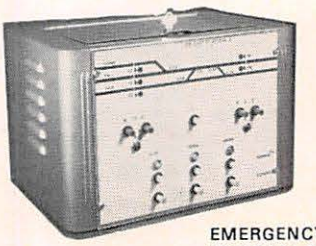
Whether short or tall, wide or narrow RACO can build a control panel to fit your specifications. From emergency control boxes to control console RACO has the capability to assemble any size to suit your needs, and in materials suitable to match your requirements.

Quality material and workmanship prevail in the manufacture of RACO control assemblies. Let us have the opportunity to study your requirements and design to match your needs.

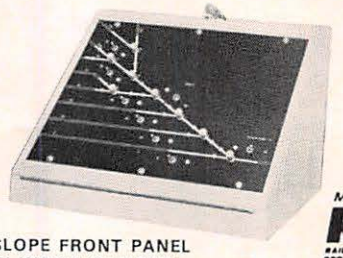
1869 1969
GOLDEN SPIKE
CENTENNIAL



RACO CONTROL CONSOLE



EMERGENCY
CONTROL PANEL
IN METAL CABINET



SLOPE FRONT PANEL
IN WOOD CABINET

MEMBER RPI RAILWAY PROGRESS INSTITUTE

RACO PRODUCTS ® ENGINEERED FOR LONG LIFE

Railroad Accessories Corporation

Main Office and Plant: 4650 MAIN STREET N.E., MINNEAPOLIS, MINN. 55421
Office and Plant: 7615 NATIONAL TURNPIKE, FAIRDALE, KY. 40118

IN CANADA: Vale Enterprises, Ltd., 1120 Claire Crescent, Lachine, Quebec

Circle 1 on reader service card

Subscription Order Card

Help yourself to a personal subscription to Railway Signaling & Communications every month. Have your own copy to read at home or in your office. Keep up with the other fellow by receiving your copy when he does. Just fill out the other side of the card below, tear it out, and drop in a mailbox.

Postage Will be Paid by Addressee

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY MAIL

First Class Permit No. 153, New York, N.Y. 10007

RAILWAY SIGNALING & COMMUNICATIONS

P.O. Box 961

Bristol, Conn. 06010

79

Railway Signaling & Communications

"is most useful to us," say readers because it provides outstanding coverage and excellent technical reporting of the fast-paced changes taking place in the field of railroad communications and signaling. It is important that those charged with responsibility for these vital operations be fully and currently informed of new developments in that area. If you are a reader—and not a subscriber—the order card attached is your invitation to receive Railway Signaling & Communications every month. Fill out the card today and mail it.

Subscription Order Form

Please enter my subscription to

RAILWAY SIGNALING & COMMUNICATIONS

☐ for two years—$5
☐ for one year—$3

☐ Payment enclosed.
☐ Bill me.
☐ Bill my company.

☐ New Subscription.
☐ Renewal.

NAME .....

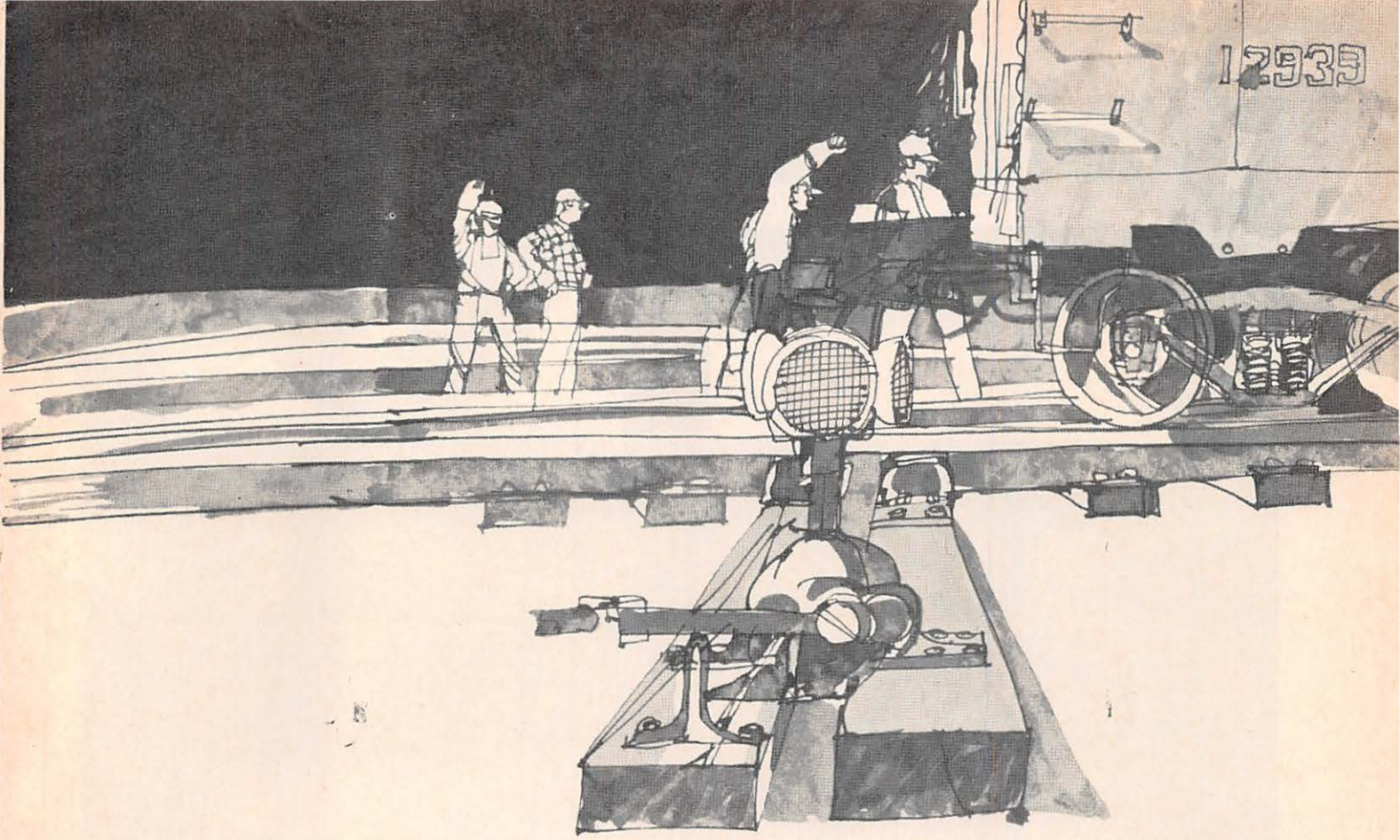
☐ BUSINESS
☐ HOME
ADDRESS .....

CITY ..... STATE ..... ZIP .....

RAILROAD .....

DEPARTMENT ..... TITLE .....

Above rates apply only to railroad men in U. S. & possessions, Canada & Mexico
Foreign and Non-Industry rates furnished on request



For Communications, Signaling, Power:

UNDERGROUND CABLE SYSTEMS

Will handle all your needs today, provide unlimited flexibility for tomorrow!

Every communications need . . . every signaling, switching and control function . . . every power requirement . . . can be accommodated with modern buried cable. And LANDCOM cable systems offer totally reliable performance, as much flexibility as you'll ever need, and reduce maintenance costs and worries to the vanishing point.

Power and communications/signaling cables can share the same right-of-way, unaffected by the weather, vandalism, corrosion, or other hazards that afflict exposed plant.

But most important, cable is the medium of the future, not only because it is free of radio frequency allocation problems (each cable has its own private RF spectrum), but because it is so easy and economical to adapt to tomorrow's needs. For instance, a 60-voice-channel system can be upgraded to 300 channels, 600, or more at minimum cost. And all along the route, new communications and signaling functions can be added at any time—wayside phones, automatic block control, hotbox detectors, TV monitors, etc.

Another big plus: cable communications systems provide superior input for computers and other automated systems. Here, reliability and the ability to pass data flawlessly are paramount considerations, and in both respects cable stands at the head of the class!

LANDCOM is ready to take your cable projects from the very outset—the preliminary study phase—to complete 'turnkey' operating systems. For detailed information about LANDCOM cable systems engineering for railroads, please contact:

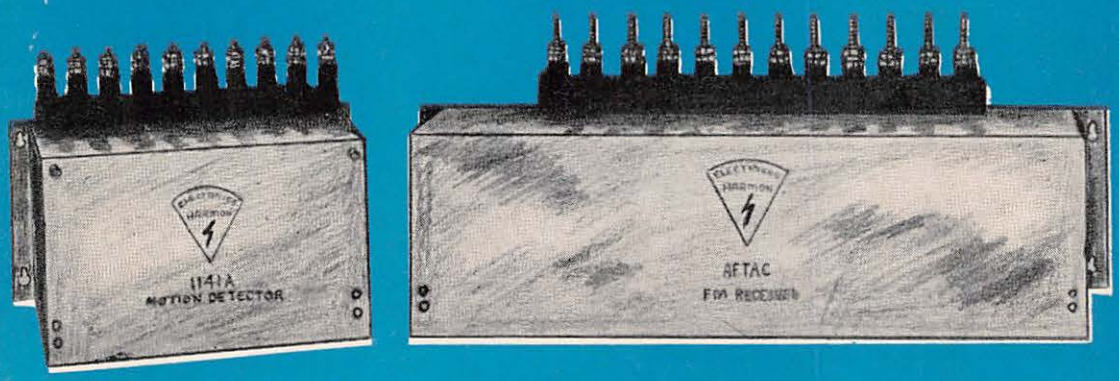
LANDCOM

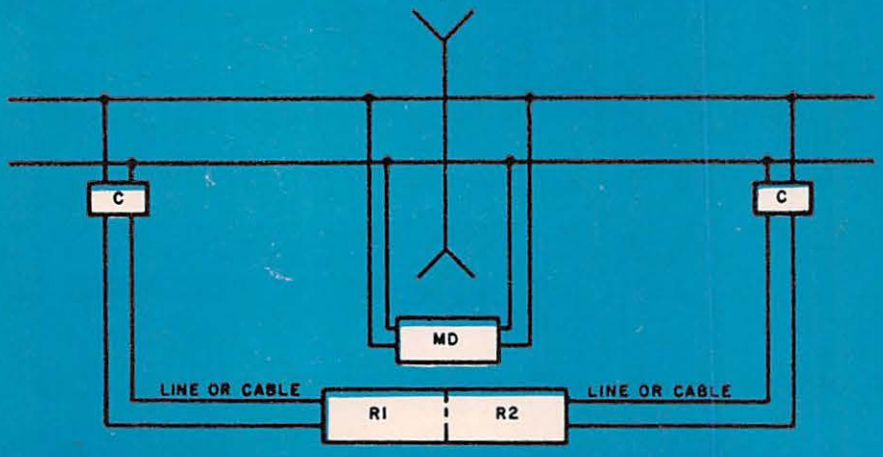
division of
UNITED STATES UNDERSEAS CABLE CORPORATION
In association with
PHELPS DODGE COMMUNICATIONS COMPANY and FELTEN & GUILLEAUME
5454 Wisconsin Avenue, N.W., Washington, D.C. 20015
Phone: (301) 654-6400 • TWX: 710-824-9612 • WUI Telex: 64132

Circle 4 on reader service card

EM

INTRODUCING A NEW HARMON PERSONALITY
THE 1173A SYSTEM





THE MODEL 1141A MOTION DETECTOR FM TRANSMITTER FEEDS TWO 1101A/ 1111A FM AFTAC RECEIVERS, PROVIDING BOTH "WRAP-AROUND" AND RE-START. SAVE FREQUENCIES IN HIGH DENSITY CROSSING LOCATIONS AND HAVE ALL ESSENTIAL EQUIPMENT RIGHT AT THE CROSSING, TOO. CALL OR WRITE US TODAY, FOR MORE DETAILED INFORMATION.

HARMON ELECTRONICS, INC.

GRAIN VALLEY, MISSOURI 64029
TELEPHONE: AREA CODE 816, 249-3112
EASTERN OFFICE: 703, 992-3338

Circle 9 on reader service card

July 1969
Vol. 62 No. 7

Railway Signaling & Communications

16 How to Select Microwave Towers

22 Electric Railway Run Trains Automatically

27 BART Controls for ATO Are Being Installed

38 C&S Are Service Organizations

40 Data Sheet 174: Data Modems

5 Editor's Corner

12 News Briefs

46 Product News

43 View from the Crossarm

Editorial Office, 29 E. Madison St., Chicago, Ill. 60602
Robert W. McKnight **Editor**
Grace Rempert Editorial Assistant

Executive Office: 30 Church St., New York, N.Y. 10007: Robert G. Lewis, Publisher; Fred B. Hecht, Production Manager; John E. Rogers, Director of Circulation.
Advertising Sales Department: C. James Fisher, Vice-President—Sales, 29 East Madison St., Chicago, Ill. 60602; Constance Nicolai, Manager of Contracts, 30 Church Street, New York, N.Y. 10007.
NEW YORK, N.Y., 10007, 30 Church St., Phone: 212-964-3060. W. Arthur Cubbage, Regional Sales Manager; Charles E. Keil, District Manager.
CHICAGO, ILL., 60602, 29 E. Madison St., Phone: 312-641-5815. C. James Fisher, Vice President-Sales; Kerry F. Sheeran, Regional Vice President; John M. Brennan, Regional Sales Manager, William J. Lyneis, Ross Mandic, District Managers.
PITTSBURGH, PA. 15219, 1230 Frick Building, 437 Grant St., Phone: 412-471-7871. Ronald M. Giallonardo, Regional Sales Manager.
DALLAS, TEX., 75206, Noel Page Building, 6400 North Central Expressway, Phone: 214-361-6972. Joe Sanders & Associates.
LOS ANGELES, CAL., 90017, 1313 W. Eighth St., Phone: 213-483-8414. Fred Klaner, Jr., The Klaner Co.
SAN FRANCISCO, CAL., 94133, 515 Pacific Ave., Phone: 415-421-7004. Lewis A. Vogler, Lewis A. Vogler & Co.
LONDON S.W. 1, England, 67/68 Jermyn St., St. James's, Phone: 01-839-6318. Max F. Holsinger; Peter Clifton; Alan Berg.
MANCHESTER 22, England, Haletop, Wythenshawe Civic Center, Phone: 061-437-3293. Ian Goulden.
PARIS, 8e, FRANCE, 70 Rue de Ponthieu, Phone: 359-65-77. Stephen Brown-Joussard.
4 DUSSELDORF-RATH, Eitelstrasse 32, 632031. Max F. Holsinger; E. Hillerbrand; Herbert Haibt; Reinhard Schomburg.
TOKYO, JAPAN, Sun Gain Shia, Ltd., Shiba Nikkatsu Bldg., 13, Shiba Park, Minato-Ku. C. H. Yiu, Managing Director.

Published monthly by Simmons-Boardman Publishing Corporation, 508 Birch St., Bristol, Conn. 06010, with executive office at 30 Church St., New York, N.Y. 10007. Second Class postage paid at Bristol, Conn. 06010 and at additional mailing offices.

Member of the Audit Bureau of Circulations (A.B.C.) Name registered in U.S. Patent Office. Printed in U.S.A. by the Johnson Press, Inc., 800 North Court St., Pontiac, Ill. 61764.

RPI RAILWAY PROGRESS INSTITUTE

AUDITED PAID CIRCULATION ABC

Subscriptions: Address all subscriptions and correspondence concerning them to: Circulation Department, Railway Signaling and Communications, P.O. Box 961, Bristol, Conn. 06010. Change of address should reach us three weeks in advance of the next issue date. Send old address with the new, enclosing if possible your address label. The Post Office will not forward copies unless you provide extra postage. Duplicate copies cannot be sent.

Subscription price to railroad employees only in U.S., Possessions, Canada and Mexico, $3.00 one year, $5.00 two years. All others $6.00 one year, $9.00 two years. Payable in advance and postage free. All other countries: $8.00 one year, $16.00 two years. Single copies 75¢.
POSTMASTER SEND FORM 3579 TO P.O. BOX 961, BRISTOL, CONN. 06010.

Editor's Corner

As you will read in our survey article this month (page 38) concerning the relationship of rail managements to the signal and communications departments, some persons express pretty strong views. By and large you will find that signal and communications departments are regarded by managements as service organizations. They are not revenue producers. True, they can save money by cutting operating costs and making a railroad more efficient.

Some opinion has been expressed by S&C men that they are not receiving the recognition that they deserve; that their status is not what it should be. Application of deeds, not words will bring the recognition that one seeks. Words, of course, are also important in bridging any communications gap. S&C men must take the initiative in mixing with others—get around and get acquainted with your fellow department heads. Keep your management aware of your presence (deeds as well as communications—oral and written). "By their deeds, ye shall know them" is an ancient phrase that still holds true today. If S&C men wait for orders from above, then they may find themselves receiving orders they do not like, feel are not right or best for the operations of the railroad. But if S&C men do not counsel management, what else can they expect?

Look around you! On railroads where S&C officers have taken the initiative in becoming knowledgeable about activities of other railroad departments and in keeping management informed, and have done the good deeds, they are recognized for their fine contributions.

Instead of passive, and sometimes active, resistance, to the industrial engineers, systems analysts, and data processing experts, S&C men should welcome these men with their special talents. By and large these "eggheads" (if you will so call them) are staff oriented and have the blessings of top management. On some railroads, their advice is directly converted into orders for S&C officers. Don't fight them, join them in making your railroad better. And least of all, don't take the attitude "it's not my responsibility."

In general, the S&C officer has the responsibility to do the best for his railroad. And that can cover a lot of ground. It can mean working closely with IEs, systems analysts, data processors and operations research people to develop the best applications of S&C equipment to the railroad. Hopefully, the article beginning on page 38 will be of some help in awakening those who only stand and wait.

Bob McKnight

Many moons ago, communications were seen and not heard

CCS has changed all that. Today, CCS cable communication systems are heard *and* not seen. Reason? We've developed the most reliable, most versatile cable system ever. And, designed it to be put out of sight, underground. Mother Nature wanted it that way.

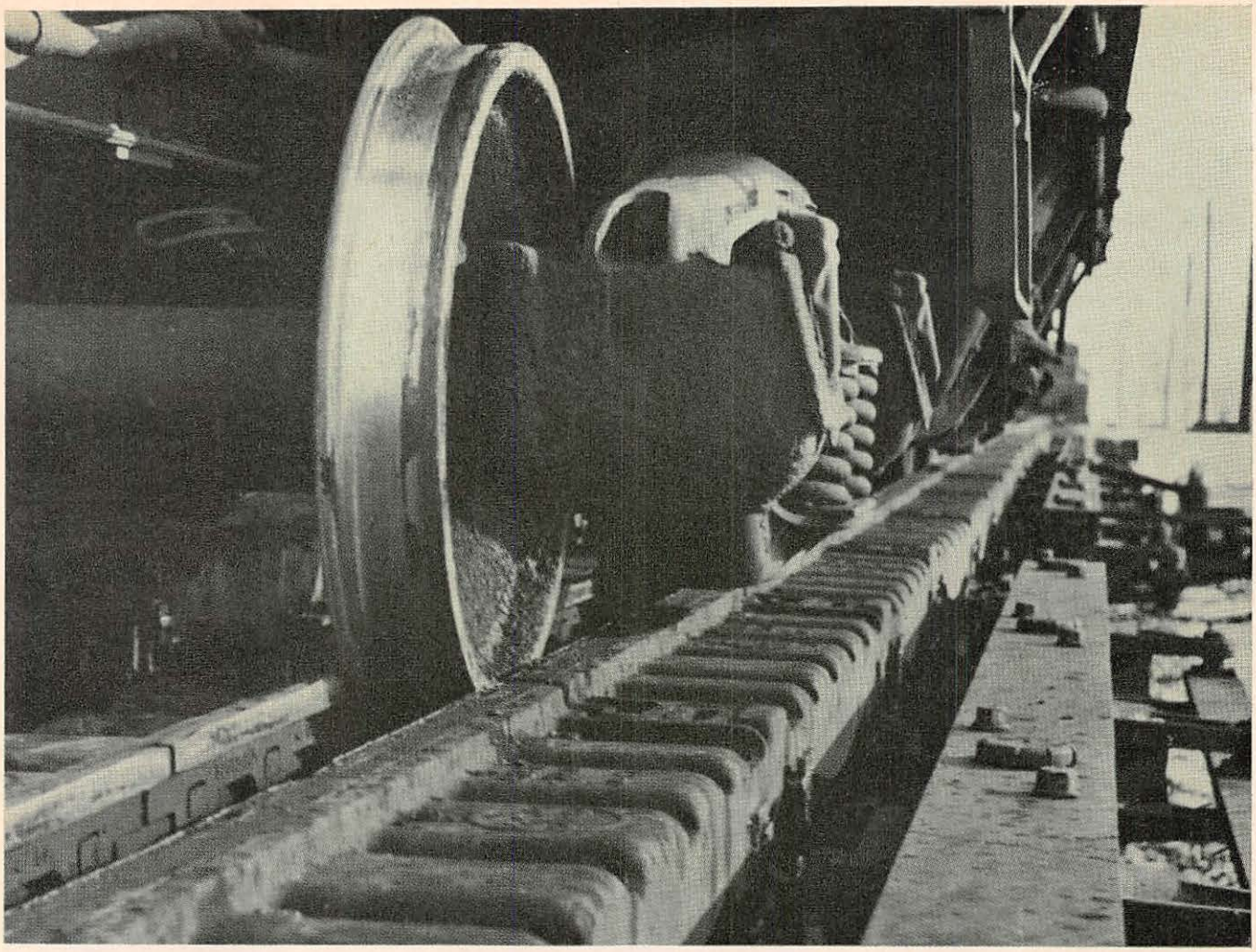
The unique CCS concept combines the finest line and terminal equipment with the revolutionary, new coaxial cable . . . Cap-Cel[tm] . . . with an unusual air-dielectric construction. CCS systems provide simultaneous transmission of voice, telemetry, control and data information. Plus, expandable capacity from 120 to 1260 channels. Results? An ideal long haul land communication system that offers greater simplicity, proven performance, high reliability, versatility, and high channel capacity *plus* low maintenance, low cost operation. CCS systems are compatible with C.C.I.T.T. and Bell System standards.

For more information on how CCS can make your communication more audible without cluttering up the landscape, write for the CCS brochure. Or, call Serge Elian, Director of Marketing, (617) 547-9000.

CABLE COMMUNICATION SYSTEMS, INC., 79 Sidney St., Cambridge, Mass. 02139

Cable Communication Systems, Inc. is a jointly owned company utilizing the technologies of the Simplex Wire and Cable Company and CIT-Compagnie Industrielle des Télécommunications, a subsidiary of CGE-Compagnie Générale d'Eléctricité.

Circle 6 on reader service card



NEW

Precision control for free-rolling cars ...up to 160 tons

GRS Type E160 ELECTRIC CAR RETARDER

No increased length—fits compactly into available retarder space.

Write for complete information.

GENERAL RAILWAY SIGNAL COMPANY

A UNIT OF GENERAL SIGNAL CORPORATION

ROCHESTER NEW YORK 14602

ATLANTA BOSTON CHICAGO MONTREAL NEW YORK OAKLAND ST LOUIS ST PAUL

Circle 7 on reader service card

3478

$80.00 a quart.

$80.00 a quart is no exaggeration. By the time maintenance crews add water to all your communications battery installations, you could pay that much . . . or more.

Cutting down on the number of times you have to add water is part of the solution. With C & D lead calcium batteries you make water additions only once every three years, or so. Conventional antimony types need water 6 to 12 times a year.

Eliminating equalizing charges is another big factor. C & D lead calcium batteries never need one if kept on the proper float charge. Antimony batteries average one equalizing charge a month, or they require a check charge at least 6 times a year. There is never a need for an equalizing or check charge with a C & D lead calcium battery.

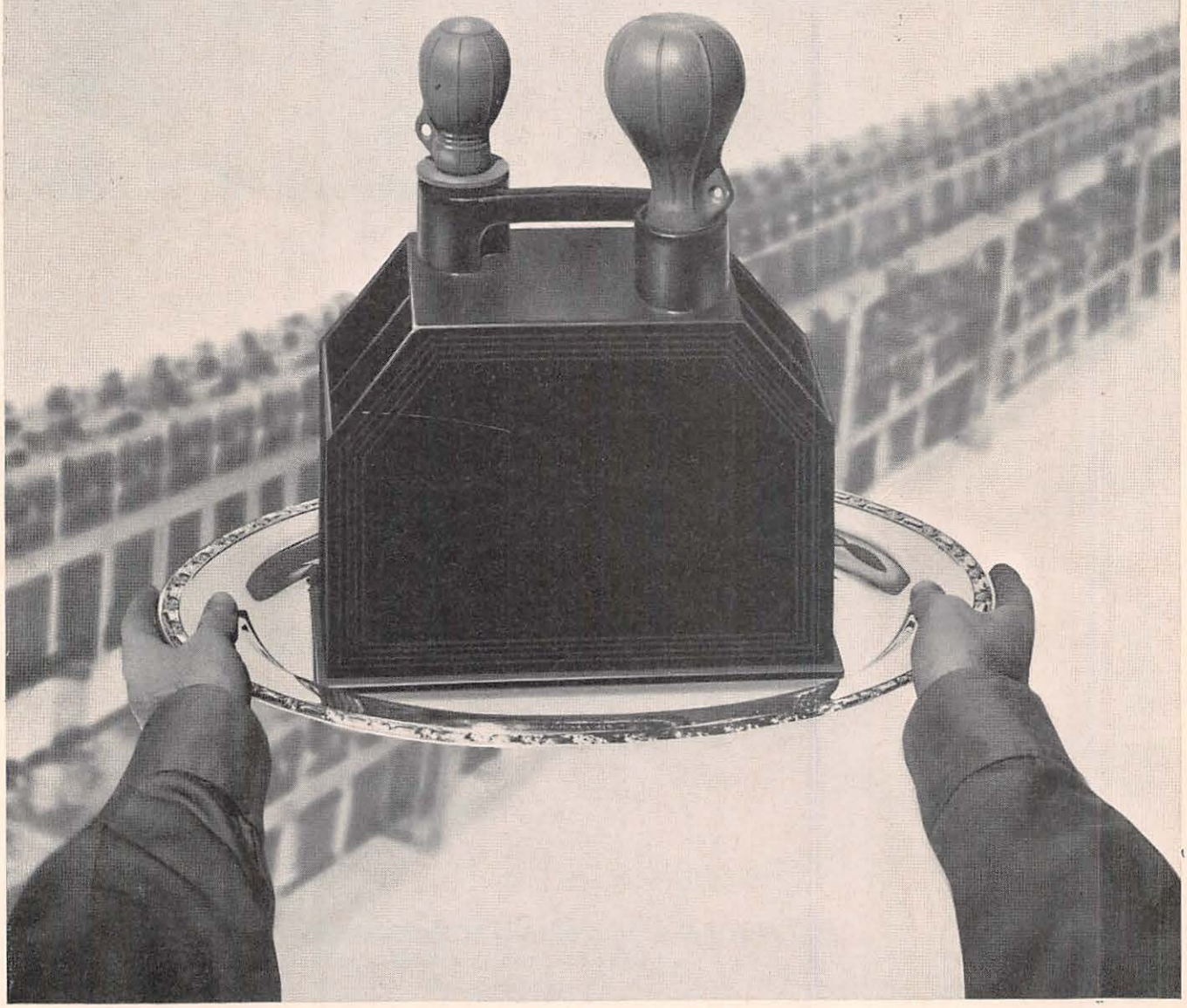
Now, will you install C & D lead calcium batteries and make up to 12 times fewer maintenance calls.

If you can't spare $80.00 for a quart of water, spare a few minutes to get the maintenance-saving facts on your communications battery installations. Write C & D Batteries, Conshohocken, Pa. 19428.

C&D BATTERIES

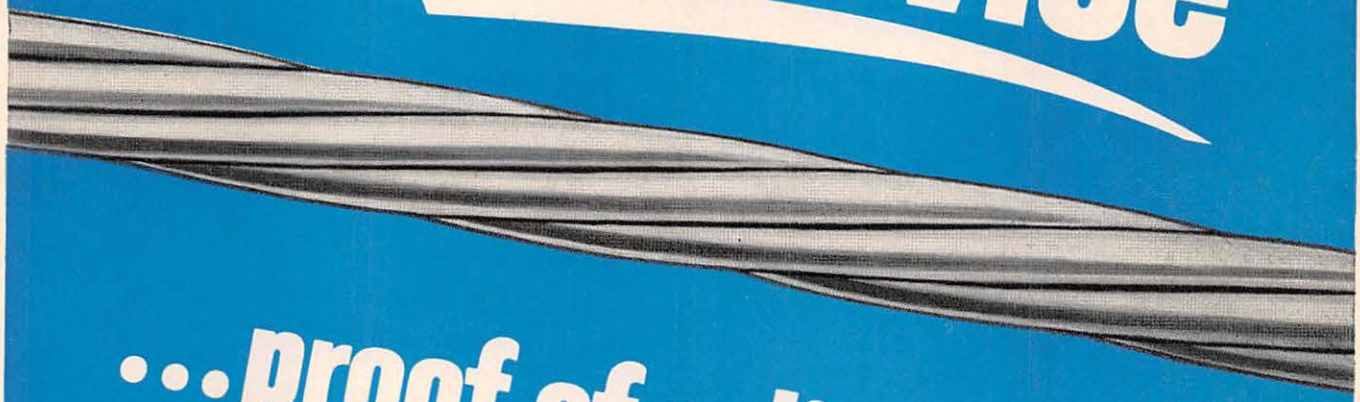
DIVISION OF **ELTRA** CORPORATION

Washington & Cherry Streets, Conshohocken, Pa. 19428



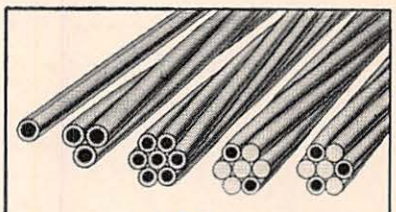
Circle 8 on reader service card

150,000,000 lbs. of Alumoweld® in service



...proof of reliability

For over 10 years, utilities all over the world—in all kinds of atmospheric environments—have depended on Alumoweld wire and strand to protect their large investments in overhead lines. Buy Alumoweld and get reliability.



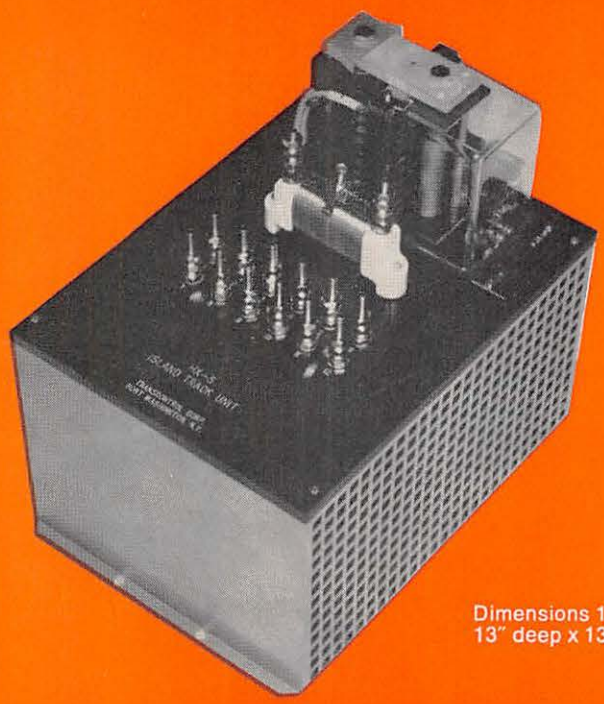
ALUMOWELD®

wire and strand

World Leader In Bimetallic Wire

COPPERWELD STEEL COMPANY
WIRE AND CABLE DIVISION, GLASSPORT, PA. 15045
For Export: COPPERWELD STEEL INTERNATIONAL COMPANY, New York

Circle 5 on reader service card

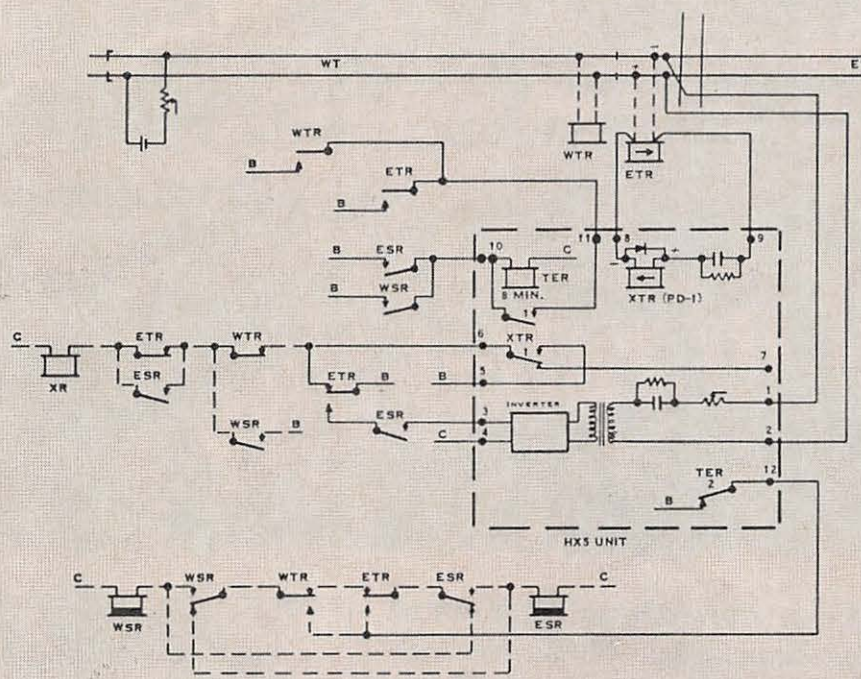


TRANSCO HX5 UNIT

FOR UPDATING EXISTING HIGHWAY CROSSINGS NOT EQUIPPED WITH ISLAND TRACK CIRCUIT

Dimensions 10″ wide x 13″ deep x 13″ wide

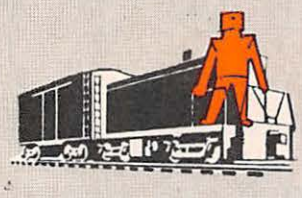
- **No additional insulated joints needed**
- **Time element feature included to prevent "lockout"**



OPERATION

1. ASSUME E.B. TRAIN.
2. WHEN E.B. TRAIN ENTERS WT, RELAY WTR BECOMES DEENERGIZED AND DEENERGIZES XR.
3. WHEN TRAIN ENTERS ET, RELAY ETR BECOMES DEENERGIZED, ENERGIZING INVERTER IN HX5 UNIT WHICH FEEDS A.C. TO TRACK LEADS OF ETR.
4. TRACK RELAY XTR DOES NOT PICK UP, DUE TO TRAIN SHUNT, UNTIL REAR END OF TRAIN IS WELL EAST OF THE ROAD.
5. AS TRAIN PROCEEDS EASTWARD, TRAIN SHUNT BECOMES LESS EFFECTIVE AND XTR PICKS UP, CLOSING CCT. FOR XR.
6. THE INVERTER, TRANSFORMER, RELAY ARRANGEMENT IN THE HX5 UNIT CAN THUS BE USED AS AN ISLAND TRACK CCT.
7. TERMINAL 2 OF HX5 UNIT MUST BE CONNECTED TO POSITIVE RAIL.
8. TIMER DROPS OUT STICK RELAYS AFTER 8 MINUTES TO PREVENT LOCK-OUT.

— — — EXISTING
——— NEW

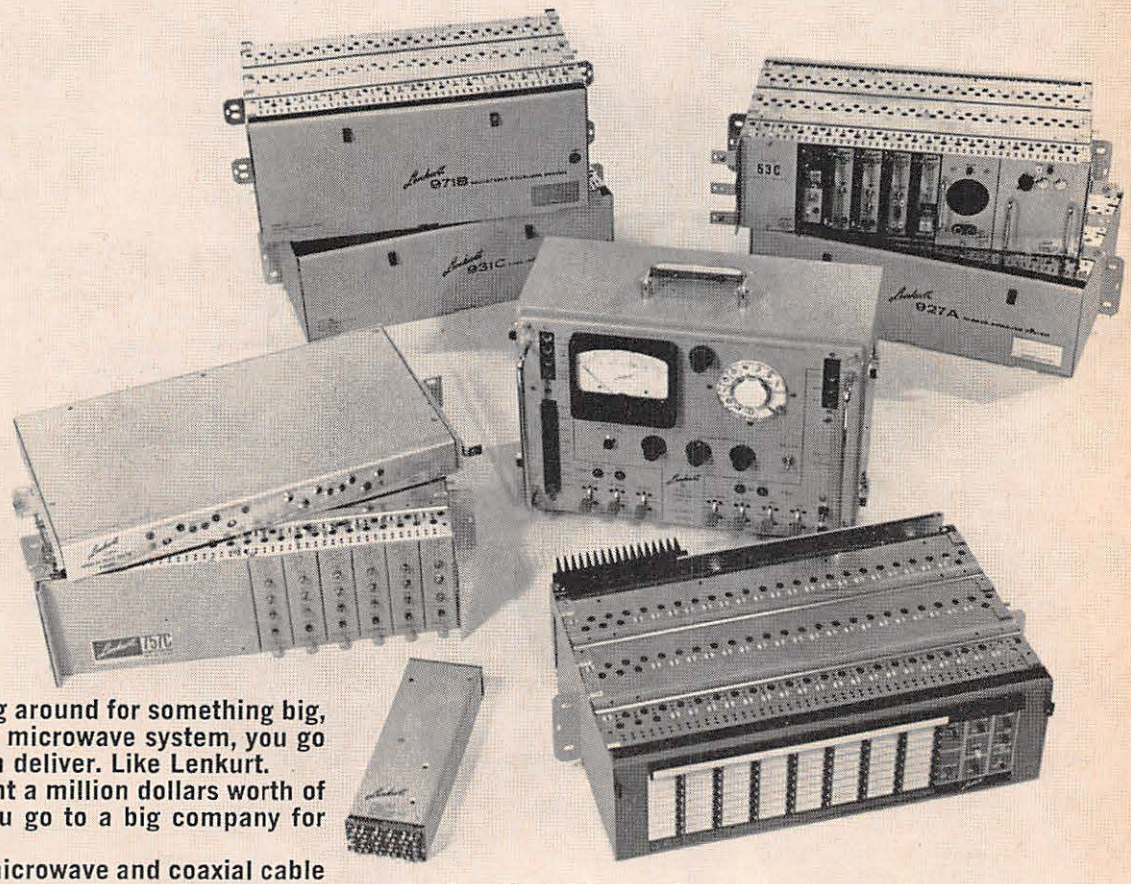


Transcontrol Corp.

TEL. 516-883-6900 • PORT WASHINGTON, N.Y. 11050

Circle 10 on reader service card

These could be the end of something big.



When you're shopping around for something big, like a multi-million dollar microwave system, you go to a big company that can deliver. Like Lenkurt.

And any time you want a million dollars worth of cable carrier systems, you go to a big company for that, too. Like Lenkurt.

And when you want microwave and coaxial cable and multiplex and cable carrier and data transmission, you definitely go to Lenkurt. Because we're the only company that makes them all.

With all the big things we do, it isn't surprising that sometimes our small-ticket items, like accessories, get overshadowed.

So, just to let you know we have them: Any time you want some four-wire terminating sets, Lenkurt has them.

Or adjustable equalizers? Lenkurt again.

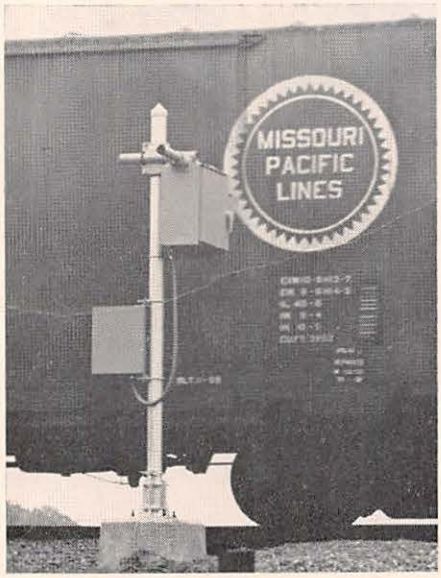
Or echo suppressors? Order wire? A microwave path protection system? A signaling system and a signaling test set? A status monitoring and alarm system? We have them all.

So when you come to us for the big things, don't forget Lenkurt makes the broadest line of the little things you need, too. Lenkurt Electric Co., Inc. San Carlos, California.

LENKURT ELECTRIC
Subsidiary of GENERAL TELEPHONE & ELECTRONICS

Transmission Accessories from Lenkurt

News Briefs



MISSOURI PACIFIC is installing five automatic car identification scanners at its freight classification yard in Dupo, Ill.

● CITY OF CHICAGO will install one set of black and white laser beam automatic car identification equipment on Chicago Transit Authority's L structure at the connection of the loop line with the Dan Ryan extension. Equipment will be provided by the Signal and Communications Division of WABCO.

● DEPARTMENT OF TRANSPORTATION and RCA have successfully demonstrated an experimental laser track inspector designed as a safety aid for future trains traveling at 300 to 500 mph. The device, a laser scanner, sweeps the railroad track with laser light beams to detect foreign objects as small as a walnut. The experimental device was installed on a section of railroad track near Princeton, N.J., and demonstrated the ability to detect an object as small as one inch in diameter.

For the test, the transmitting-receiving system monitored the track with laser pulses that were bounced back by a retro-reflective "fence" positioned along the opposite side of the track.

In operation, a series of operational laser devices could provide complete coverage of the roadbed. Should an object such as a rock or tree limb obstruct the roadbed, the laser would detect it and signal a central facility so the object could be removed before it hindered a train. The central facility could also transmit an advance warning to an approaching train so it could stop if the object could not be removed before the train reached it.

The experimental system used a transmitter-receiver employing a Gallium Arsenide laser stationed 3.5 ft from the roadbed. It scanned a 89-degree arc, providing coverage of 600 ft. An operational system could scan a 178-degree arc to cover 600 ft on either side of the laser for a total of 1200 ft.

The retro-reflective fence along the opposite side of the track resembles the aluminum strip fences now found by many highways, except the reflecting strip is narrower and has special plastic molded reflectors imbedded in it. The laser has been designed to operate in a wide variety of weather conditions, from rain and fog to sunshine, without sounding false alarms or missing an obstruction. It can handle a variation of 100 to 1 in intensity of the laser beams returned from the retro-reflective fence.

● FLORIDA EAST COAST has ordered Grade Crossing Predictors from Marquardt Industrial Products Company to be installed at 24 streets in South Miami and West Palm Beach, Fla. for the automatic control of highway grade crossing protection equipment.

● LOUISVILLE & NASHVILLE is planning to install automatic car identification scanners at 86 locations generally at yards and/or interchange points.

● MILWAUKEE ROAD has applied to the Federal Railroad Administration to discontinue automatic cab signal system between Brookfield and LaCrosse, Wis., 182 miles; between River Junction and Hastings, Minn., 106 miles; and between Mayfair, Ill. and Lake, Wis., 69 miles. Operation will then be by existing automatic block signaling and existing traffic control systems. Reasons stated in the application are:

The railroad believes safety of train operation will be improved by removal from service the controlled automatic cab signal system, thereby, eliminating the extremely serious hazard of improper operation due to interference caused by stray currents in the rail from 60Hz AC power from outside sources.

Maximum speeds do not exceed 79 mph, therefore, controlled automatic cab signals are not required.

The segments involved herein represent only 20% of the 3,506 track miles of wayside automatic block signals in service. The railroad is certain that safety of train operation can be maintained without cab signals in these segments. Experience over the years has clearly demonstrated the adequacy of wayside automatic block signal system for train operation.

The cab signal system wayside equipment is not provided with standby power. Therefore, it becomes inoperative when an interruption or outage occurs in the 60 Hz power supply. Power failures therefore result in additional false restrictive indications impeding train movements unnecessarily.

The equipment is obsolete. Procurement of repair parts is difficult and on special order basis.

OPENING SALES ENGINEER

Signal and Communications Engineer to sell lightning and surge protection equipment, devices, and services to the R.R. industry and the R.R. O.E.M. market. Position requires a BSEE, or equivalent, and requires travel from office in Greater Chicago area. Please write, stating qualifications and salary expected, to: **F. A. KAHL, Joslyn Electronic Systems, P.O. Box 817, Goleta, Calif. 93017.**

Ruby B. Blaylock
Frisco

John J. Swiss
T. A. Edison

Railroad Personnel

● CANADIAN NATIONAL: **J. E. Skinner**, regional research officer Winnipeg, appointed manager, management services there.

● CHESAPEAKE & OHIO BALTIMORE & OHIO: **C. L. Horne** appointed signal application engineer and **W. A. Jones** appointed leading signal application engineer with headquarters at Huntington, West Va.

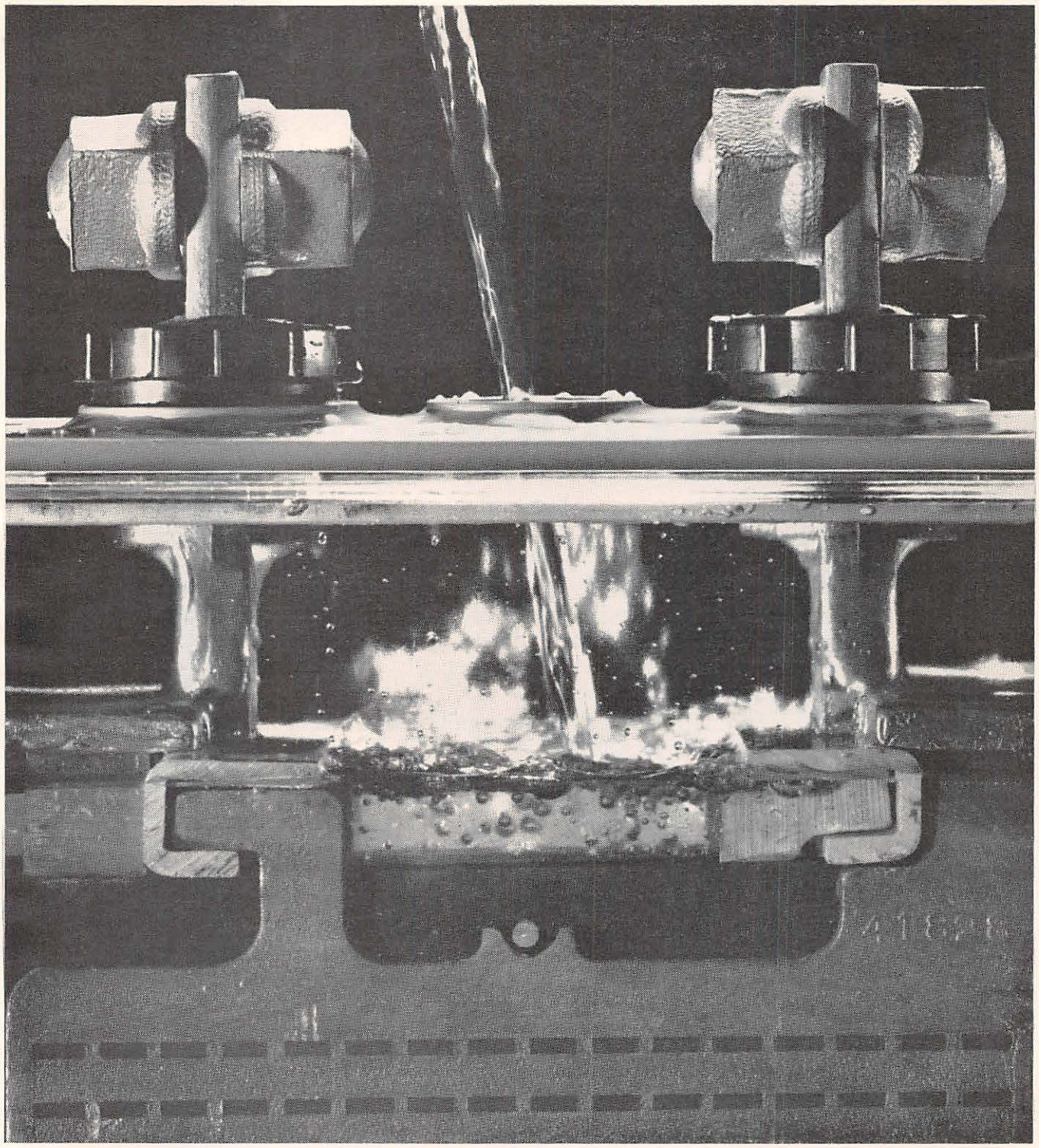
● MISSOURI PACIFIC-TEXAS & PACIFIC: **Arthur E. Anderson** appointed manager-management information system installation.

● NORTHERN PACIFIC: **Harry H. Coolidge, Jr.**, manager of data processing, appointed director of data processing at St. Paul.

● PENN CENTRAL: **D. M. Geist**, supervisor communications and signals, Pittsburgh, appointed project engineer communications and signals with headquarters at Philadelphia.

● FRISCO: **Ruby B. Blaylock**, superintendent communications, was born February 26, 1920, at Grenada, Miss. He joined the St. Louis-San Francisco as a communications maintainer at Memphis in 1955. One year later, he was promoted to assistant communications and signal supervisor there, and, four years later, transferred to Ft. Scott, Kansas. In 1961, Mr. Blaylock was promoted to communications supervisor at Springfield, Mo. In 1967, he was promoted to project engineer, communications and signals. In April 1969, Mr. Blaylock was promoted to superintendent communications with headquarters at Springfield, Mo.

(Please turn to page 41)



We put more acid in our batteries so you'll get more power out.

We try not to overlook anything that will make Gould batteries for signalling and communications the best you can get. Designing our battery jar to hold extra acid (and lead) is one example. Our jar is slightly larger . . . and stronger, too. The extra acid we can get into it gives us longer periods of discharge. Simply, it results in more power—longer—per interruption.

A little thing, jar design? Perhaps. But we think it's attention to the "little" things that has earned Gould's reputation of being leaders in signalling and communications batteries.

Little things, too, like delivering the batteries and chargers you need when you need them.

We'd like to tell you all about Gould stationary power systems for signalling and communications. Write *Gould-National Batteries, Inc., Ind. Battery Div., 467 L Calhoun St., Trenton, N. J. 08607.*

GOULD NATIONAL BATTERY POWER

Circle 12 on reader service card

For Microwave Communications, You Can't Beat This Combination –

For voice communication, the Lynch solid state B910B single side-band suppressed carrier multiplex–reliable, compact and flexible–is ideal for new microwave multiplex applications and for modernizing existing systems. The B910B provides typical Lynch optimum transmission quality and can be custom tailored, both electrically and in rack profile. As an example, there is almost an unlimited variety of frequency allocation plans to suit your particular requirements.

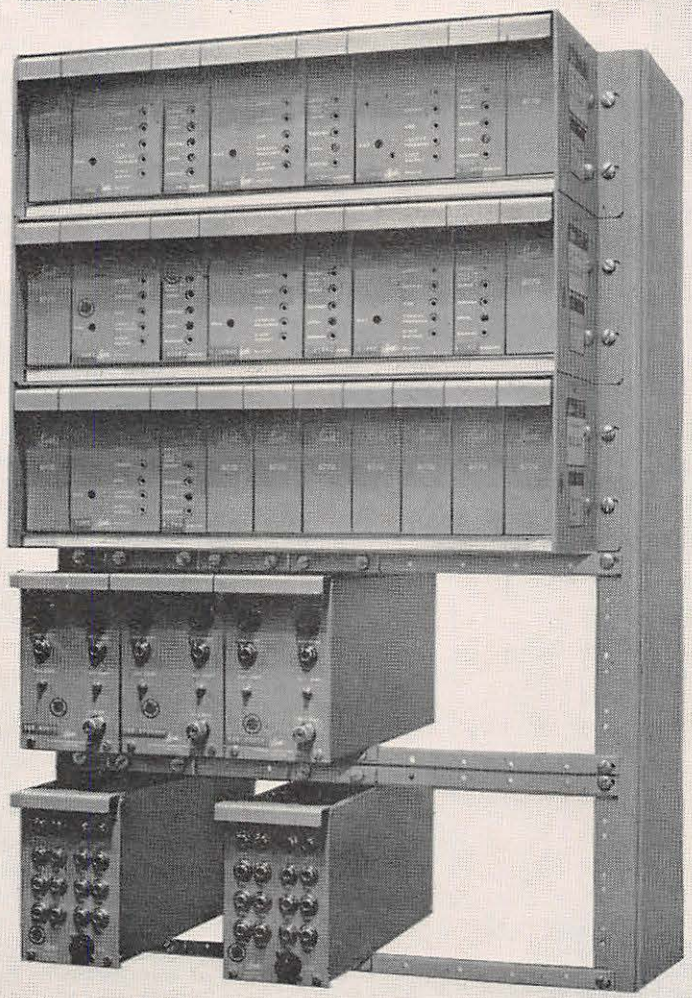
The Lynch B770 tone carrier equipment is an ideal combination to be used with the B910B. The B770 is insensitive to noise and phase variations. Reduction of bias distortion and minimization of false operation due to spurious signals are provided by this frequency-shift type of equipment. Reliability is further enhanced by the 35 db (minimum) adjacent channel receive filter rejection which reduces crossfire, crosstalk, and noise to a minimum. The B770 is a superior device for telemetry, telegraph, supervisory control, monitoring and alarm reporting.

Lynch products are easily adaptable to your present or proposed system and are fully compatible with the best industry standards. As with all Lynch equipment, the B770 and the B910B are backed by an undisputed record of top quality and service.

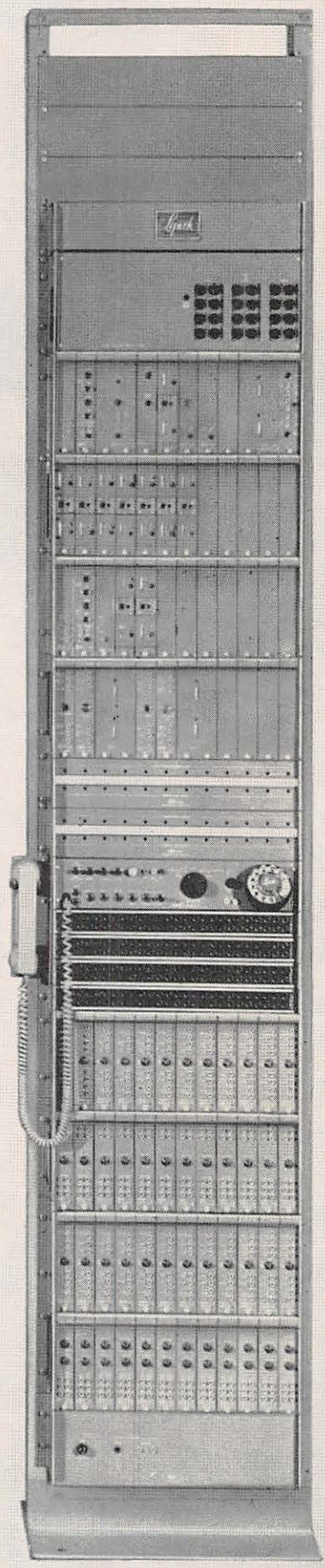
For any communication problem, talk to a man that speaks your language–the Graybar Communication specialist. You can get in touch with him through one of over 140 Graybar offices.

Go to the source: GraybaR

LYNCH B770
installed in 19″ rack



LYNCH B910B
installed in 19″ rack



Circle 14 on reader service card

How to select microwave towers

By Grady Rooker
Assistant Sales Manager
Rohn Manufacturing Co.

Sometime, as a railroad communications man, you have had or will have the occasion to consider towers. This could happen on a small scale with two-way radio base station towers or, more to the point, with microwave towers as you plan your initial or expanded system. Too often this is not done. The communication engineer, being well versed in electronics but barely familiar with structures, will not really consider the tower portion of the outside plant.

We admit that the tower is most prone to be taken for granted. Being passive, non-electronic and with no moving parts, a properly designed, fabricated and installed tower-antenna system will just "stand there and work." It will require a minimum of periodic preventive maintenance and seldom, if ever, cause path loss. Your job, then, is making sure that the structure is properly designed, fabricated and installed. Because towers are Rohn's only business and we are one of the "World's largest exclusive manufacturer of TV and communication towers," we can perhaps offer some suggestions to assist in your considerations.

A good way to start might be to review the areas where we can be of little or no help, decisions which probably will have been made before you contact a tower supplier to assist you in preparing a specification. These include site selection, determination of whether to use a self-supporting or a guyed tower, and the decision as to how you will buy the towers—from the radio equipment manufacturer as part of a "turnkey" installation or by breaking them out of the package and buying them direct from the tower manufacturer.

The selection of a proper microwave relay site involves many factors other than that of the tower. These factors

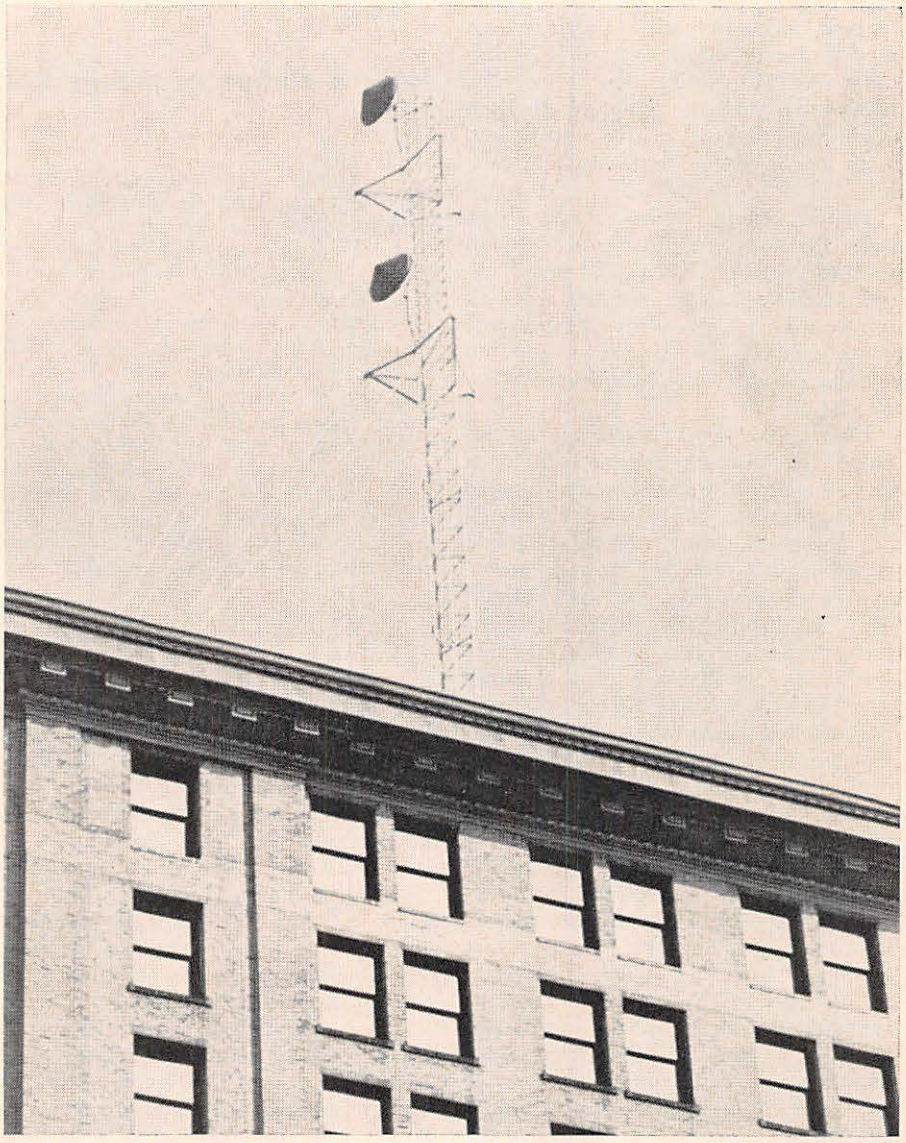
have been well published, involve considerations of path and real estate availability and cost. They can most properly be resolved by the engineers of the radio suppliers, by your right-of-way department and yourself. Because we are considering railroad communications systems, it would appear that site selection offers somewhat different problems than in other industries. You will probably require your relay stations to be primarily along your right-of-way. As to the tower determining the site, it is obvious that if elevated sites are available (mountains and building roofs), you may save the cost of a tall tower. Don't leap into such a conclusion, however, because often the cost of clearing a hilltop site or the sometimes prohibitive cost of preparing a roof foundation and then erecting the tower thereon may exceed the price of a taller tower on a more normal site.

The question of self-supporting vs. guyed towers is raised a surprising number of times. Most tower manufacturers offer both. Naturally, the self-supporting structure, being far heavier, will cost more than the equivalent guyed tower. The increment of difference will depend on tower height and wind and antenna loading. A rough rule of thumb is that a microwave self-supporting tower 100 ft to 200 ft tall with average loading capabilities will cost installed about two to three times the equivalent guyed structure. For short towers in the 40 ft to 60 ft range, a self-supporting structure will often cost no more than a guyed tower, while in the 400 ft and over range, a self-supporting tower may well cost ten or more times the guyed structure. Land considerations alter these ratios, of course, We have seen a proportionate increase of self-supporting to guyed towers each year for the last decade as suitable sites become harder to locate.

Tower manufacturers will provide plot configuration recommended for the height guyed tower you require. Rohn includes this as standard catalog specification information. It is also true that guyed towers can be designed to fit onto undersize or odd-shaped sites. Tower companies are always happy to assist in this special planning. Other, more individual considerations than cost and site, including aesthetics and susceptibility to sabotage or accidental damage, sometimes enter into this decision. But, it is not true that one tower is preferable to the other structurally. A properly designed and installed guyed tower is equally strong and should, if properly maintained, have a life equally as long as an equivalent free-standing structure. Also, the self-supporter is not more prone to cause path loss because of excess twist or sway than a tower which is guyed against these movements. The points are frequently raised, but simply have no validity.

The direct vs. indirect method of tower procurement should be carefully considered. Certainly you will pay more for towers by having them included in a turnkey system, because the equipment manufacturer must add an increment for handling and profit. Also, you retain a much greater control of product by buying direct. However, if you include the towers with the radio equipment, you place responsibility for total system performance directly in the equipment supplier's hands, eliminating any future question of liability in the event of path fading or loss. The details and burden of procurement and installation are his, as well. We have often found that a communication manager installing his first system will purchase the complete package, where often on system additions he will buy the towers himself.

As for the towers themselves, the best advice Rohn can offer is to write a specification, or have one written for you. This should be done whether



Guyed towers may be placed atop buildings to gain elevation.

the towers are to be bought directly by the railroad or through the system supplier; otherwise you will likely receive the minimum possible structure. It is not sufficient to simply state that towers are to meet the requirements of Electronic Industries Association Standard RS-222-A. While in some respects this document is the communication tower industry's "bible," it must be emphasized that RS-222-A is a standard, not a specification. Most microwave tower manufacturers design their product in conformance with this standard; yet, it is not unusual for the customer, when reviewing several tower bids for a particular system, to find significant differential in price and product offered, with all bidders claiming to meet RS-222-A.

This recommended "specification" may actually be more of a statement of work as you need not enter into design formulas or structural details. Items which should be considered include:

Material: Here RS-222-A will be of help to you. Require that all material be new, and, whether of U.S. or foreign manufacture, that it conform to minimum ASTM specifications. Recently, many suppliers have upgraded their materials, at least in the tower leg, from an ASTM A7 or A36 steel to a high-strength, 50,000 lb yield steel.

Bolted Connections: Require all bolts for structural joints to be high strength per ASTM A325, where required. Secondary connections, especially where bolts are under ½", may be of lower quality. You would do well to ask that all structural bolted joints have a lock nut.

Finish: Whatever else you do, include the absolute requirement that all members be hot-dip galvanized after fabrication. No other finish should be accepted. Most reputable tower suppliers will provide this as a matter of course. Rohn Mfg. Co. maintains its own hot-dip facilities, but all manufacturers have access to such facilities. Under no conditions accept a paint-over-black-steel finish. (See RS-222-A).

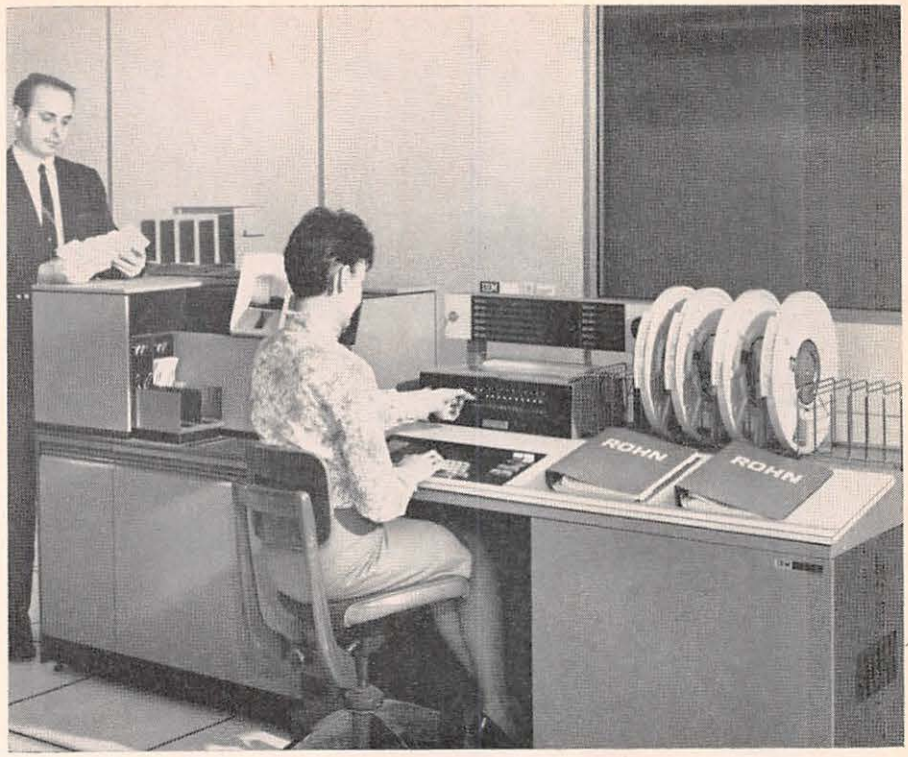
Paint and Lighting: A properly hot-dip galvanized communications tower need not be painted for corrosion protection. There remains some controversy on this point, and a very few tower users still require extensive and expensive paint protection over zinc, but the majority of the industry accepts hot-dip galvanizing for corrosion protection. It may be necessary, however, to add one coat of paint, in alternate orange and white stripes, over the zinc for the purpose of aircraft warning identification. This would be required by the FAA and is generally true for all towers over 200 ft. Occasionally, towers under 200 ft must be painted, but again, this determination will be made by the FAA prior to granting permission for the tower to be there at all.

Any tower requiring warning identification painting must be lighted, as well, and the converse is true. The lighting is standard and conforms to FAA specifications, and is available through the tower supplier. At Rohn, we manufacture many of the items which form the lighting kit.

Towers can be painted either in the factory or in the field. More and more users are specifying that the tower be bonderized and receive a prime coat of paint at the factory, and this is advisable whether the finish paint is applied at the factory or in the field. The primer allows for easier application and longer life of the finish coat.

Tower Loading: The antenna and reflector loading is determined by the radio path; wind and ice loading is not. The more data you can give about antenna and reflector loading to the tower designer, the more precise the result. Naturally, you must provide the number and size of the antennas, but in addition, specify their elevation on the tower and their azimuth orientation. Provide the size of the waveguide and coaxial line, as well.

The wind loading specification requires a determination on your part,



How a computer serves Rohn and its customers

To improve its service to customers Rohn Manufacturing Co. has added the digital computer as one of its designing tools. Computer usage enables the designer to specify the right tower for the right job in less time than formerly using pencil, paper, charts and desk calculator. An IBM 1130 is computing in about 30 minutes what formerly took about one man-day of effort. The calculations of stress analysis are done by the computer.

Although towers are constructed of building-block or modular sections, Rohn really custom designs for each specific use, as for example, microwave or VHF radio. Speed plus accuracy in handling repetitive calculations have made the computer an invaluable asset for Rohn's tower designers.

Often, Rohn engineers are called upon to provide budget estimates to customers who are planning extensive microwave systems. One recent project consisted of 47 towers. Rohn estimators, using the computer, were able to obtain computer calculations using only two hours of computer time. The same work would have required several days using hand methods.

Towers are essentially assembly jobs using the proper sections to obtain a tower that will be rigid enough to withstand wind and ice loading. Also, it must be able to support antenna microwave dishes in proper alignment. And naturally, the de-

ROHN MANUFACTURING CO.
COMPUTER ANALYSIS
SELF-SUPPORTING TOWER STRESS ANALYSIS

100 FT. SSV TOWER FOR XYZ RAILROAD
WIND LOADING = 30 PSF E.I.A.
TWO 10 FT. DIA. DISHES AT 95 FT.
TWO 10 FT. DIA. DISHES AT 55 FT.
INSIDE LADDER FOR CLIMBING
ONE RUN OF EW-59 WAVEGUIDE TO EACH DISH
TWIST AND DEFLECTION FIGURES ARE SHOWN FOR THE DESIGN WIND LOADING
3-17-69

INPUT PARAMETERS

ANTENNA LOAD (SQ. FT.)	ANTENNA ELEV. (FEET)	ASSUMED TORQUE (FT-KIPS)	PROJ. AREA OF LINES SQ.FT./FT.)	HEIGHT ABOVE TOWER JOINT (FEET)
117.80	95.00	9.60	0.34	15
117.80	55.00	9.60	0.34	15

LEG MOUNTED LADDER = 0.400SQ. FT./FT.

TOWER SECTION NUMBER	JOINT ELEV. (FT.)	FACE WIDTH (FT.)	TOTAL SHEAR (KIPS)	MOMENT (KIP-FEET)	LEG STRESS (KIPS)	LEG CAPACITY (KIPS)	LEG SIZE (INCHES)	BRACE STRESS (KIPS)	BRACE CAPACITY (KIPS)	BRACE SIZE (INCHES)	ACCUM. WT. (KIPS)
9KD-STR	80.	10.54	4.700	64.679	7.085	32.700	2.5 STD	2.411	2.620	1.75X.125	1.000
10KD-B	60.	12.58	6.008	171.770	15.766	32.700	2.5 STD.	1.967	4.420	2.00X3/16	2.090
11KD -B	40.	14.62	11.360	363.122	28.679	48.700	3.0 STD.	3.650	5.780	2.50X3/16	3.480
12KD -B	20.	16.67	13.228	609.005	42.184	47.700	3.5 STD.	4.034	7.040	3.00X3/16	4.989
13KD -B	0.	18.67	15.256	893.849	55.282	62.200	4.0 STD.	4.125	6.780	3.00X3/16	6.679

THE MAXIMUM TENSION IN ONE LEG = 53.055 THE MAXIMUM COMPRESSION IN ONE LEG = 57.509

THE TOTAL TOWER DEFLECTION = 0.190 DEGREES THE TOTAL TOWER TWIST = 0.105 DEGREES

signer must select sections that will have sufficient structural strength to support lights, ladders, waveguides, and other appurtenances as well. Tower design is really a structural engineering problem.

Typical computer input data for a self-supporting tower is as follows: 100 ft self-supporting tower with two 10-ft microwave antenna dishes at 95 ft elevation, two 10-ft antenna dishes at 55 ft elevation, an inside ladder for climbing, one run of EW-59 waveguide to each dish. Also included is such structural data as antenna load, assumed torque, section number of tower selected, etc. Using values already in the program for shear, stress, bracing sizes, etc., the computer calculates various structural values for this self-supporting tower. From the print-out, the designer can determine if he has chosen the correct tower sections. For example, if the print-out shows a leg capacity less than the leg stress, he knows that he must rerun the calculation using a tower section of greater capacity. This can be accomplished very quickly using the computer.

Rohn engineers have also developed a computer program for calculations involving guyed towers. As in the other tower calculations, the print-out will show all pertinent information as to types of guys and anchors used, etc. This will enable the designer to provide cost estimates to customers. Also, the computer results can be used to prepare shop orders for actual filling of customer orders.

The computer is but one of many useful, modern tools provided for Rohn designers and engineers to enable them to give customers better sevice. Additionally, Rohn's airplane provides fast, on-the-spot coverage by company engineers to customers' locations. Founder-President Dwight Rohn and Vice-President Richard A. Kleine find the plane a useful tool for bringing them promptly to customers' locations.

As noted elsewhere in the accompanying article, customer service plays a key role in the success of Rohn Manufacturing Co.

and here you will trade dollars for the insurance of added safety and a reduced possibility of failure. Standard EIA RS-222-A includes a map of the U.S. which divides the country into three zones. The large portion or majority of the country is designated as Zone A, equivalent for a microwave tower to a 30 or 35 lb per sq ft (approximately 86 to 93 mph) wind loading. We have found that in recent years customers tend to be more conservative than the EIA standard (indeed, many local building codes so dictate), and the average tower being specified is probably 40 lb (100 mph). If icing is prevalent in your area, it would be wise to require the tower to be designed for at least ½" of radial ice. Use EIA RS-222-A as a minimum and proceed from there. The tower designer has experience in the matter of loadings, which may prove valuable to you.

Future Loading: This is a factor too often overlooked by the system designer. Is there a possibility that in the future a simple repeater station will become a three or four-way junction as spurs are added to the system? If so, you should estimate the future antenna loading and specify that the tower be designed to accept it. There are many cases of towers being overloaded by the indiscriminate adding of antennas and reflectors subsequent to initial installation. To a lesser extent, the same can be said about adding height to an existing tower. The initial increment of extra cost for so specifying is usually not great and, in any case, is preferable to replacing the entire structure.

Calculations and Documentation: This is perhaps the most important of all these considerations, as it is the one most often ignored with the most damaging results. Require a stress analysis, stamped and signed by a registered professional engineer, and require that one be provided for each tower in the system. This should be provided after award of contract, of course, as it involves considerable en-

gineering expense. The analysis can be in the form of a computer readout, because more and more companies either own computers (as does Rohn) or design with computers by means of time sharing programs, or it can be tabulations resulting from personal, hand calculations by the engineer.

Such an analysis, by either method, is your only assurance that your towers were designed to your specifications, rather than being the standard, all-purpose design of your supplier. Stress analysis will prove that the particular tower is strong enough to withstand the specified wind and antenna loading, and, also, that it will be within the critical twist and deflection limitations.

Along with the stress analysis, require erection-outline drawings for each site. These should also be signed and stamped by the engineer and should include as a minimum the following: (1) Railroad and the designation of the particular site; (2) Other information normally included in a drawing title block; (3) The outline of the tower showing critical dimensions and member sizes and manufacturer's model number: (4) Foundation details, including size, depth, reinforcing bar required, and special instructions pertaining to the installation of the concrete; (5) The exact antenna loading, initial and future; (6) Wind and ice requirement; (7) Twist and deflection limits.

These drawings and analysis should be retained by you and the tower company. At Rohn we maintain indefinitely a copy of the erection-outline drawing for every microwave tower we have sold. Your future need to add loading to the tower will be greatly enhanced if you and the tower supplier can refer to this documentation in years to come. Your specifications should call for your supplier to keep these records available to you for your future needs and reference. If your towers were purchased through a radio manufacturer, he should also keep complete files on your towers.

Access to Tower Top: There are numerous ways to ascend a communication tower, such as step bolts on one or more legs; ladder, outside on the face or within the cross section; climbing on the braces, if they are so positioned; or, infrequently, in an elevator. There are several extra features available, such as climbing safety devices, ladder cages, and rest and work platforms, to better provide safety to personnel. Decide what you feel is necessary and clearly specify same. If you overlook this item you will most likely receive step bolts or horizontal tower braces spaced for climbing.

Users sometimes tend to be ultra-conservative in providing climbing and safety devices and may well spend a considerable sum for equipment never used. The key question to ask is who will be climbing the tower after installation to maintain the structure itself and maintain and adjust the antennas and reflectors. If you or persons in the communication department intend to climb, then you will at least require a ladder, and a climbing safety device and one or two rest-work platforms at critical levels would be helpful. If you will subcontract all maintenance work and adjustment to experienced tower riggers, it is best to save this money. A rigger would probably use the ladder, but doesn't need it. The climbing device and platforms would probably be ignored as they get in his way and aren't positioned where he could use them.

Lightning Protection: EIA RS-222-A calls for two ⅝" by 8 ft ground rods at the base of a guyed tower, with one similar rod at each anchor, all rods connected to the tower by at least No. 6 copper lead. We recommend that each leg of a self-supporting tower be grounded with an 8 ft rod. This standard is intended as a minimum and many customers adopt more stringent requirements.

Unless you are a structural engineer or employ one, excess detail can only restrict design and may well add to your tower cost without resulting benefit to system performance. Despite the limitation of EIA RS-222-A this standard should be referenced by your specification, and by doing so you are eliminating the possibility of improper design. Also, sales engineers for tower companies (alas, including this writer) will be most happy to assist in the preparation of your specification. Their help can be valuable, but guard against including tower details indigenous to only their particular tower. Items most properly avoided in the writing of the specification are such design and construction details as tower shape (three vs. four legs), guying methods (three way vs. four way, guy levels and radius, etc.), type of structural shape used for leg and brace (angle vs. tube), type and method of bracing, and antenna-tower and reflector-tower interface details, and tower construction (welded vs. bolted-knock-down).

Your specifications and the supplier's standard product line will dictate whether the tower company will bid a square or triangular self-supporting structure. Rohn offers both so, having no ax to grind, we feel safe in saying that, properly designed, one or another will suffice in any given situation. Generally, the triangular free-standing tower will be lighter than a square one of the same basic construction, and thus will be employed for shorter heights and lighter loadings. There are exceptions to this. If a tower has a very heavy antenna-reflector loading, or one is anticipated to expand in the future, you could consider the square tower simply to have the extra face upon which to hang antennas.

Stress analysis should be made on each microwave tower, and documented.

ANGLE VS. TUBE

The question of "angle vs. tube" is one long discussed in the communication tower industry. Again, Rohn offers both, and has in its product line tower series which, in effect, "compete" with one another, similar in many respects except that one is constructed of angle and the other of tube. In the early days of microwave communication, in the late forties and early fifties, there were instances of tubular, non-galvanized towers failing because of internal corrosion. This occurrence is almost unheard of now. Some tower manufacturers will hermetically seal their tower legs to prevent the entrance of any moisture. Others, like Rohn, will galvanize the tube inside and out after fabrication and will design the tower and foundation such that any small amount of moisture which enters the leg will immediately drain out, preventing corrosion and also the possibility of a leg splitting due to ice formation. Either method is acceptable. An angle tower must be heavier than its equivalent in tube, and this is one good test for evaluating competitive tower bids. The reason for this is perhaps obvious: the tubular tower, being more "streamlined," offers less surface to the wind than one made of angle or other steel shape.

Much time can be spent on antenna-

tower interface details, which, in almost all cases, buys the user nothing at all. If the system uses passive reflectors, these are most often available from the tower supplier, who is quite able to design the proper attachment brackets and tie-backs. A few tower manufacturers do not make or supply reflectors, but they are still able to design and supply the interface, given the reflector make and model. Almost without exception, microwave parabolic antennas have standard mounting clamps which accept mounting pipes up to 4½" outside diameter. The tower supplier will include such a pipe, when specified, to be located off the tower face or leg as orientation requires.

There is one final item of structural design sometimes broached by tower users and the preference for one or the other is quite perplexing to tower engineers. This is the choice of either a welded, one piece or a bolted, knock-down tower section. In the former, the braces are welded to the tower legs at the factory and the section, usually 10 or 20 ft long, is shipped and erected in one piece. A knock-down design utilizes braces which are bolted to the legs, wherein the parts are shipped separated and the sections are assembled on the site prior to erection.

To the user, the economic advantages and drawbacks of each method generally offset. The welded tower will incur considerably more freight charges than the knock-down, whereas the latter will require the erection crew to "shake out" and assemble on site. The result is an erected tower of about the same price, whichever design is selected. For export projects, Rohn suggests knock-down tower designs wherever possible, both because of lower cube and, therefore, freight and also because of less susceptibility to damage during repeated handling, but these considerations are not very important for domestic systems.

Facts are scarce when structural preference is expressed for either welded or knock-down on the basis that one is stronger or produces a "straighter tower," than the other. To our knowledge, there are no statistics for engineering rationale to support either case. A well designed bolted joint should be as strong and lasting as a well designed and fabricated welded joint. Generally welded towers are smaller in cross section and subject to lesser loads, while bolted designs are greater than 3 ft in face width, but there are a number of exceptions to this.

Having written the specification some attempt should be made to use it in the evaluation of the tower quotation. Your responsibilities to evaluating are naturally more strigent if the railroad is to place the purchase order for the towers, but don't step completely out of this process if buying turnkey. As the customer, you should be entitled to work with the OEM (Original Equipment Manufacturer) and, in a general way, exercise control in the selection of vendor of important components. The OEM will be devoted to providing a superior microwave system, but may be placing emphasis on the electronic equipment of his own manufacture. Economic considerations could dictate his choice of an adequate, but not superior tower.

By using a company airplane, Rohn engineers can provide fast service.

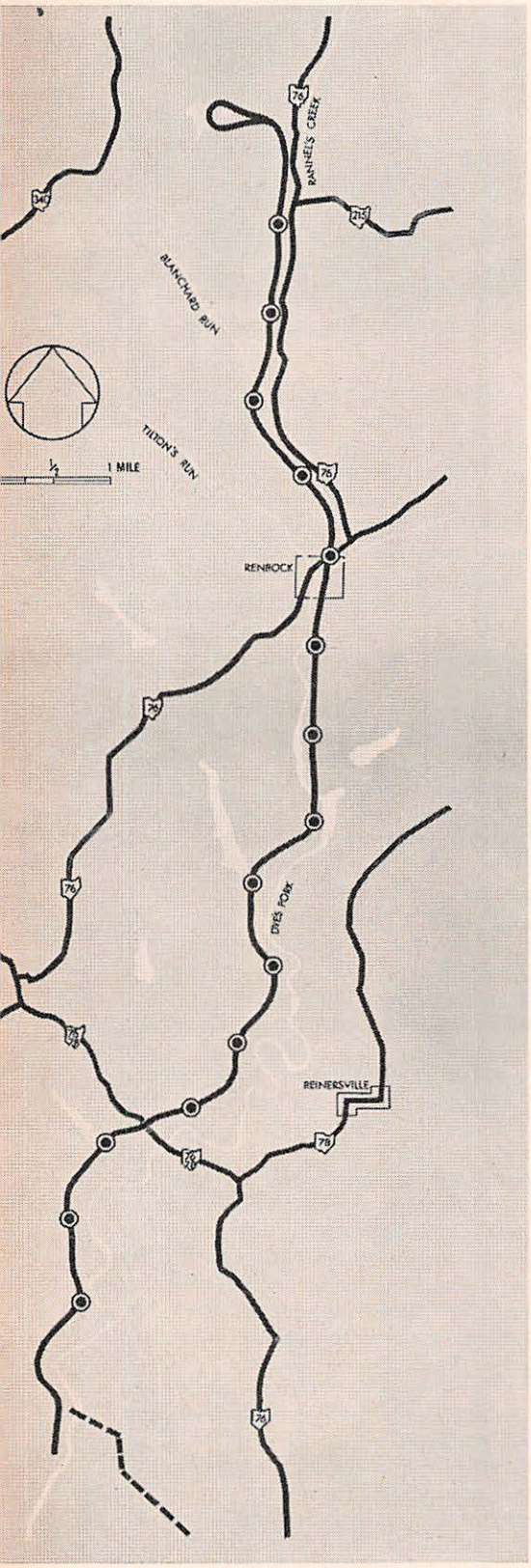
Considerations used when evaluating tower bids and suppliers are generally the same ones used when evaluating any proposal for capital equipment. You should try to evaluate the prospective supplier's history and current participation in the mocrowave industry, and financial stability and potential for performing on schedule. Determining the extent of past participation in this industry is simple: have the supplier list the number of systems for which he has provided the towers. These need not be in the railroad industry (although such would be familiar to you and easier to verify), as from a tower standpoint the employment of the system in the industry of the user is inconsequential.

The existence of current activity in this industry should be questioned: Is the prospective vendor really in the microwave tower business or does he make communication towers other than microwave, or is he a steel fabricator seldom involved with towers at all? There are four or five competent firms in the U.S. currently quite active in the design, fabrication and installation of microwave towers. A number of other companies make communication towers (broadcast, CATV, two-way radio, military antenna supports), but seldom are involved with microwave structures. They may or may not be in a position to provide the small nuances of design and installation necssary for a superior tower: torque guying details sufficient to hold tower twist and deflection within prescribed limits, sturdy reflectors and reflector supports with proper interface to the tower, and installation crews skilled in the fine-tuning orientation of dishes and reflectors, and the installations and connections of waveguide and coaxial cable.

Financial stability becomes most important with choosing a tower vendor for large, multi-hop systems. He will have to have access to sufficient funds to buy steel and, more important, to pay his subcontractors as he proceeds through the installation of the system. The ability to deliver on schedule is admittedly difficult to determine but a visit to the vendor's factory would probably help. Does he maintain a large inventory of raw material or even of fabricated tower sections? How close is he located to a galvanizer? Is the engineering department large enough to handle design and documentation of more than one job at a time? In fact, are there one or more registered engineers on the payroll, or must he rely on outside consultants? Is primary method of shipment by rail, or motor freight, or are there trucks owned by the tower company capable of being used for direct shipments from the factory to remote, barely accessible tower sites?

Our intent is not to turn communication engineers into structural experts, but to provide a small measure of assistance in the matter of specification and selection of microwave towers. As microwave systems become more sophisticated to meet the stringent requirements and demands of data transmission, it becomes more important to employ outside plant components of such quality so as not to compromise performance of radio equipment.

Electrified railway operates



Approach position indicators are spaced about 4,000 ft apart along the line (circles on map)

William B. Robertson
Sales and Application Engineer
Transit Systems Department
General Electric Company

The Muskingum Electric Railroad, located near Zanesville, Ohio, will haul a weekly minimum of 90,000 tons of coal 15 miles from a Central Ohio Coal Co. tipple to the Muskingum river power station stockpile. Two crewless integral trains, each with a General Electric E-50, 5,000-hp straight electric locomotive as motive power will shuttle back and forth over the railroad.

The two trains will be made up so that loaded consists will be pulled and empties pushed. Each train will have an assigned leg of the loading loop with the empty train being "checked in" at the loading loop before the loaded train is dispatched. Therefore, only one train at a time will be on the mainline.

The General Electric automation system controls all train movements between the terminals of the railroad, as well as the loading and unloading operations, giving a completely automated transportation system. Basically, the automation system consists of wayside sequence and interlocking controls at the terminals; on-board sensing, regulating, and safety control; and communications and supervisory control.

Communication with the trains will be by one of two methods—continuous or intermittent. This approach provides trains with a minimum investment in wayside equipment.

The continuous communication is provided by type 52 tone modulated carrier current equipment specifically designed for railroad service. The carrier transmitter output frequency is 200 KHz at 2 watts. This carrier is modulated by audio frequency tones ranging from 67 Hz to 115 Hz in steps of approximately 5 Hz. All carrier equipment, both on-board and wayside, is powered by 24 volts DC.

The wayside antenna loops are mounted on the catenary poles using standoff insulators. The antenna is in the form of a loop with a three-foot "window". The loop is located on the poles at a nominal height of 11 ft above the rail head. The antenna conductor is No. 4 stranded aluminum.

There are two continuous command receiving antennas on the locomotive. They are mounted on the "A" side at each end of the locomotive platform.

There are six antenna loops in the loading area and one in the unloading area. The use of multiple loops in the loading area permits controlling both trains simultaneously. A train operating in this area will receive a continuous tone signal, the specific frequency of which indicates the mode of train operation. At this installation the following signals can be sent: running speed—pulling; zero speed (stop); running speed—pushing; north direction; yard approach speed; south direction; unload speed; creep speed.

Each communication loop will be capable of transmitting only those commands which are required for normal operation over that portion of the railroad. The lack of a continuous signal when required will result in an emergency stop of the train.

The carrier communications concept is also used so that the locomotive can "talk back" to the wayside in order to confirm that a change of direction command has been executed properly. A transmitting antenna is mounted under the platform on the "B" side of the locomotive and a wayside pickup coil is mounted at the location where the locomotive will be commanded to change direction.

The locomotive has a carrier transmitter whose transmitting frequency is a function of the locomotive reverser position. That is, when the reverser is "forward" the signal frequency transmitted will be 174.9 KHz. But in the "reverse" mode the frequency will be 175.1 KHz. This permits the wayside logic to ascertain that the locomotive has received and properly executed a change direction command before a speed command is transmitted.

The intermittent communications system is used on the mainline portions of the railroad and provides a periodic signal indicating the desired speed to the train. This periodic signal is provided by an inert wayside device mounted between the rails, in pairs, about every 4,000-ft. along the railroad main line. These units called API (Approach Position Indicators) units, contain piezoelectric elements tuned to specific frequencies. By selecting combinations of different frequencies unique signals can be encapsulated with the API unit.

In this application, the coding system used will be the single digit 2 out of 5 bit (1247C) code. There are four mainline speeds which must be trans-

unit-coal trains automatically

mitted by the API units. These are: (1) running speed—pulling; (2) running speed-pushing; (3) dynamic braking speed; and (4) zero speed (stop).

The coding corresponding to these speeds is as follows:

	Code Frequency				
Speed	1	2	4	7	C
1		X		X	
2		X	X		
3	X	X			
4	X				X

The locomotive mounted equipment consists of a signal transceiver and decoding logic mounted in the short hood of the locomotive and an antenna mounted under the locomotive behind the No. 1 truck. The antenna is located approximately six inches above the rail head.

The locomotive mounted transceiver must receive a signal consisting of two and only two frequencies. When a valid signal is received, it is stored in memory and a second signal from the same API unit will be accepted. This signal will be compared with the first, and if it checks, the proper output line to the on-board regulator is momentarily energized.

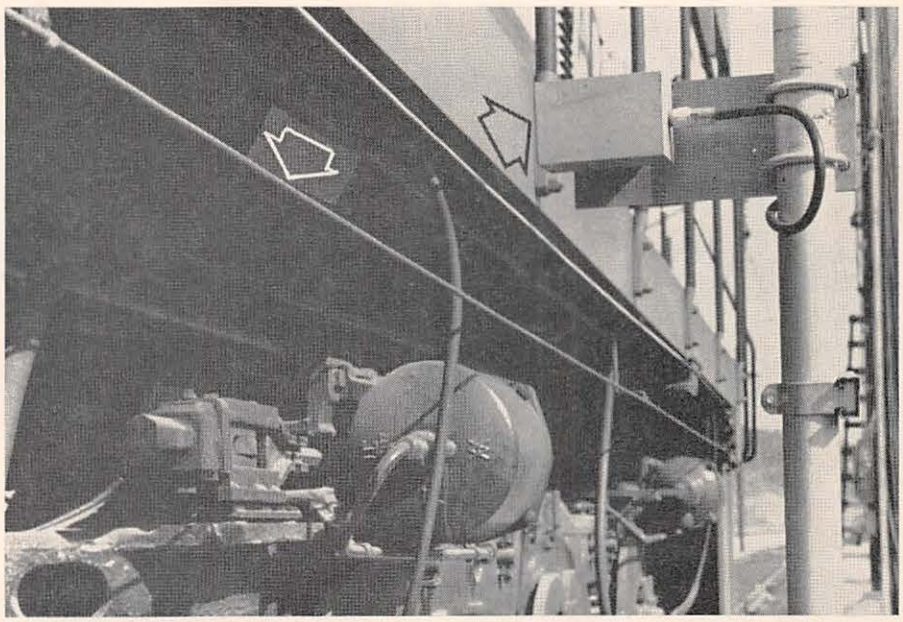
A distance measuring circuit within the on-board regulator is reset upon receipt of a signal from the wayside API unit. If another API unit is not read within a prescribed distance, the train will be placed in an emergency stop condition. By reading an API unit at regular intervals the train is permitted to proceed over the mainline. The distance counter can be calibrated to take into account wheel wear.

The API units are placed along the right-of-way in pairs to permit northbound trains to operate at a different speed than the southbound trains. The units are located such that the last one of the pair will be acted upon by the on-board regulating system.

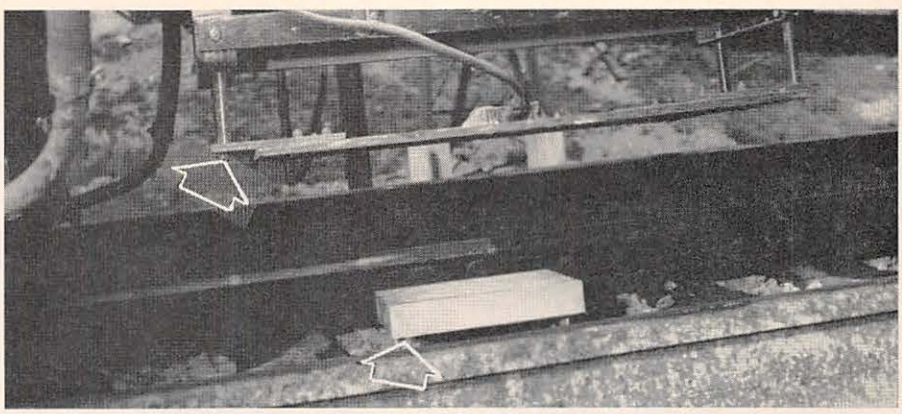
The last API unit before a continuous communications zone will be coded with a zero speed causing the on-board regulating system to begin a programmed deceleration. The zero speed command will also switch the communication mode from intermittent to continuous. As the train continues to decelerate, it enters the first continuous communications loop which is keyed for a zero speed. The wayside equipment will check this train in and determine that it is safe to enter the terminal.

(Please turn to page 26)

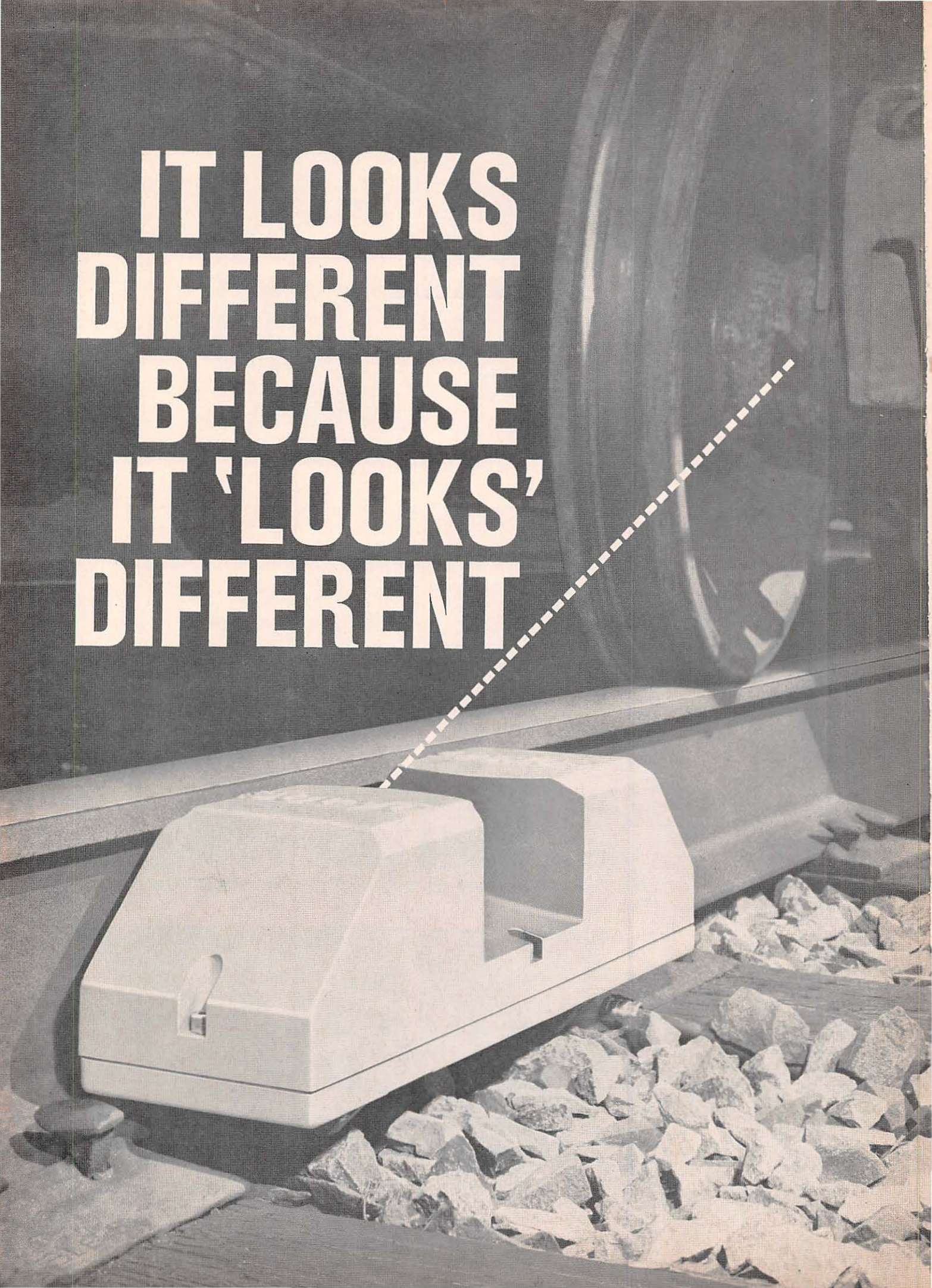
Continuous command receiving antenna on "A" side of locomotive.



Transmitting antenna wire on locomotive feeds wayside pickup coil on pole.

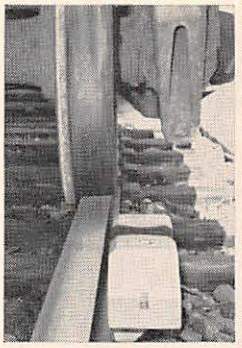


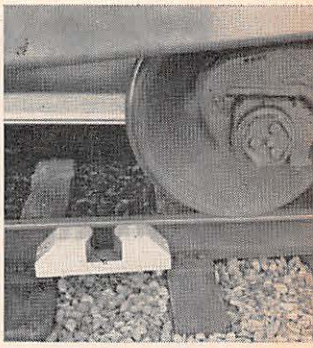
Locomotive transceiver antenna passes over approach position indicator.


IT LOOKS
DIFFERENT
BECAUSE
IT 'LOOKS'
DIFFERENT

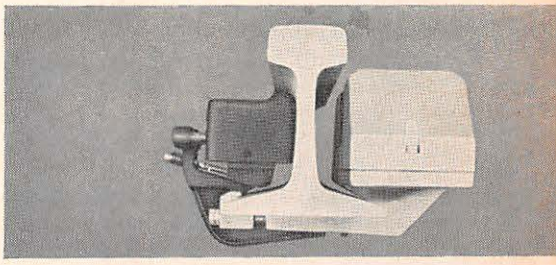
Announcing the new Model 8808 Servosafe® Hot Box Detective™ with RAIL-MOUNTED SCANNERS PATENTED

CLOSE-IN TARGET "LOOK" FOR UNIFORMITY AND ACCURACY
The Model 8808's rail-mounted scanner looks vertically at the bearing journal *behind* the truck frame. This provides a clearer, more uniform scan of the journal, unaffected by truck lateral motion, wheel size variations, or obstructions such as springs and equalizers. The distance between the scanner and journal target is significantly shorter, resulting in increased detection sensitivity and accuracy under all operating conditions including extreme weather. The system is completely compatible with all types of roller and friction bearing journals, regardless of frame or housing configurations.

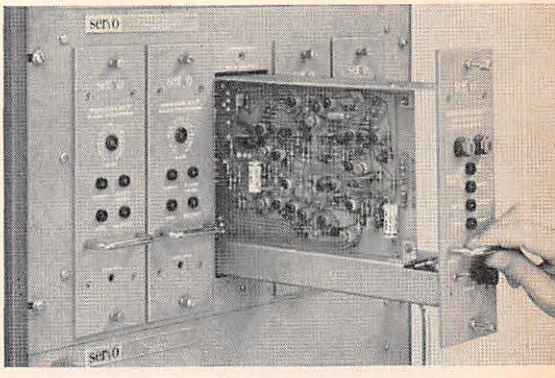




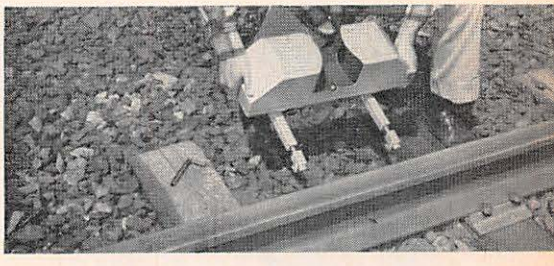
NOT AFFECTED BY RAIL OR BALLAST CONDITIONS
The scanners and gating transducers are securely clamped to the rail. Drilling is not required. Target-scanning accuracy is not affected by rail pumping, running, or lateral movement since there is no relative motion between the scanner and the wheel. There is no requirement for special roadbed stability or special rail anchoring. Alignment is permanently fixed, eliminating repeated re-alignments and adjustments.



ADVANCED DESIGN SOLID-STATE ELECTRONICS
Finest quality semiconductors and plug-in electronic modules assure maximum reliability and service life. A unique signal processing circuit and precise, instantaneous gating offer greater accuracy of detection and fast system response, independent of train direction and speeds from 5 to 150 mph. Smaller differential signals and higher system gain allow earlier detection of overheated journals. The fast-acting detection system, together with the behind-the-truck-frame scan, excludes spurious heat sources that could cause false indications. Power requirements are considerably less —battery power can be used for standby operation. Panel space has been reduced by the compactly packaged, plug-in modules.



REDUCED INSTALLATION AND MAINTENANCE COSTS
Installation costs are appreciably reduced by the elimination of concrete foundations, special ties and roadbed preparation. The scanner housing's aerodynamic design prevents the accumulation of foreign matter, thus minimizing the need for optical system cleaning and maintenance trips. If relocation is ever required, the scanner can be removed from the rail quickly and easily, without special tools or equipment.



If you're looking for the latest in hot box detection equipment that can increase safety and efficiency while reducing operating costs, take a look at the Model 8808, the system with the new "look" that's been field-tested for more than two years. Ask for our Tech Data Publication 2020.

servo

servo corporation of america
railroad products
111 new south road
hicksville, new york 11802
516-938-9700

MEMBER RPI

MUSKINGUM ELECTRIC

(Continued from page 23)

The on-board automation system receives the speed commands from the communication equipment in control and translates them into a speed reference for the Automatic Train Operation (ATO) equipment. This reference can be adjusted so that the exact speed desired can be obtained. The design speeds for the Muskingum Electric are:

Running Speed—Pulling	– 50 mph
Running Speed—Pushing	– 35 mph
Dynamic Braking Speed	– 25 mph
Yard Approach Speed	– 15 mph
Unload Speed	– 4 mph
Load (creep) Speed	–1/3 mph

The train is checked in by a wayside proximity switch. A vane on the locomotive activates this switch as it passes and additional switches are positioned around the loading loop to check the position of both trains. Wayside logic control will interpret these switch signals and provide the proper speed commands to the various carrier antennas.

In this manner the empty train is admitted to the yard and the loaded one dispatched. Under normal operation, the yard approach speed tone signal will be sent before the train has slowed down appreciably. Thus, the initial zero speed signal provides the required safety, but does not restrict train operation.

When a train is traveling from a continuous communication zone to the intermittent zone, a mainline running speed tone is transmitted to the locomotive. As the locomotive leaves the continuous communication zone it passes over a pair of API units, thereby starting the distance measuring circuits for the intermittent operating zone.

The on-board regulator senses locomotive speed and regulates it by applying power or brakes as required to maintain it at the desired level. There are two identical tachometers, each mounted on an axle of the locomotive. These tachometers provide a square wave AC signal whose frequency is proportional to locomotive speed.

A comparison of these two independent signals is made to insure they agree within limits, and the larger of the two signals is compared with the speed reference dictated by the wayside command. In this manner, a failsafe speed regulating signal is obtained.

In addition to the required speed reference, there is also an overspeed signal set slightly above the desired speed. Should the speed signal exceed the overspeed reference, an emergency stop will occur.

A transitional speed (and also overspeed) reference is initiated when a more restrictive speed is called for. This transitional speed signal can be adjusted to obtain an optimum deceleration rate even though the train weight should vary.

The GE automation system also controls the trains during the load and unload cycles of the operation. Thus, these operations also are performed without requiring any manual control.

The cars are loaded from an overhead tipple at a rate of 50 tons per minute as the train creeps underneath at approximately ⅓ mph. Proximity sensors similar to the one used for train detection are used to control the chute gates. These sensors are at a different height than the train detector sensors so that the vanes on the car will have no influence on train detection.

Two sensors are used for each direction of travel and the wayside logic will select the proper pair to correspond to the locomotive being loaded. As the front end of the car passes under the chute, the gate opens. The height of the chute is located to provide for "plug-loading" of the cars. As the end of a car approaches the chute gate closes and the remaining coal in the chute fills the car. This cycle is repeated until the train is full.

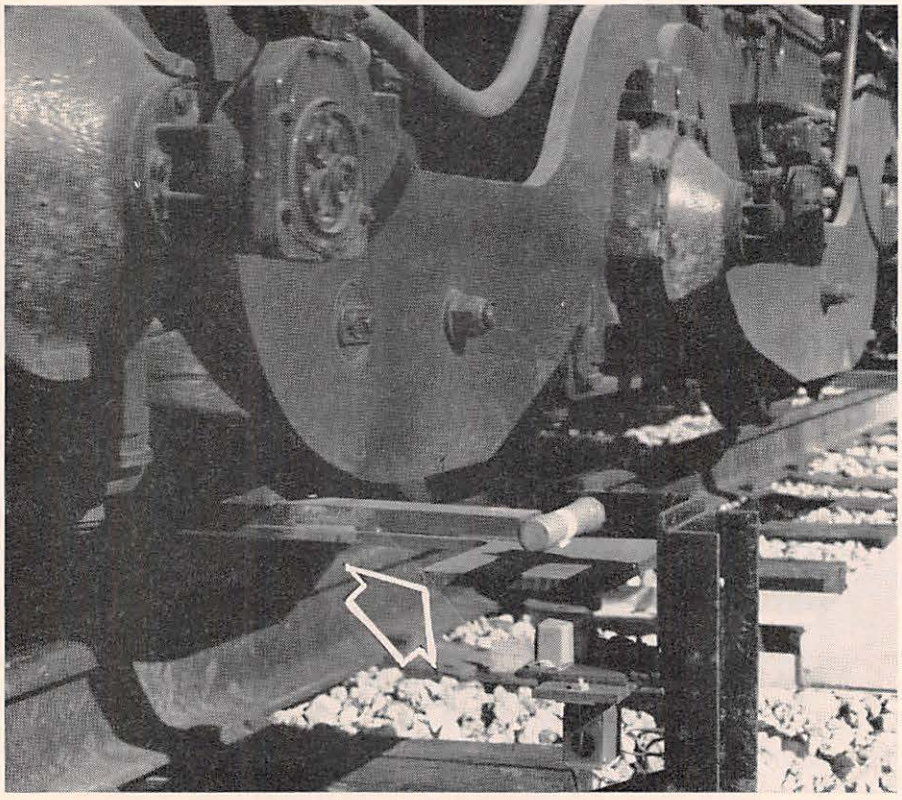
The cars are rapid discharge, hopper-bottom type, designed for unit train service. The car doors are air operated and controlled by a polarized double acting magnet valve. A collector rail mounted on the car truck will engage a heavy duty railroad type collector shoe on the wayside to transfer low energy power for operating the magnet valve.

The train is unloaded "on the fly" at about 4 mph. There are two dumping locations with the odd cars dumping at one location and the even cars at the other. The collector shoes are alternately energized to accomplish this unloading sequence.

A third shoe is energized with "close door" polarity and is located at the end of the dump area to close the car doors.

After the train has been unloaded, and reversed, all three collector shoes are energized with "close door" polarity. This will provide additional checks to insure all car doors are closed for the return trip.

The use of unmanned automatic trains on American Electric Power System's Muskingum Electric will provide dependable around-the-clock service. Inclement weather and poor visibility will not impair the ability of the trains to operate on schedule. Programmed train operation will permit optimum use of equipment well within its design limits—thereby keeping maintenance at a minimum.

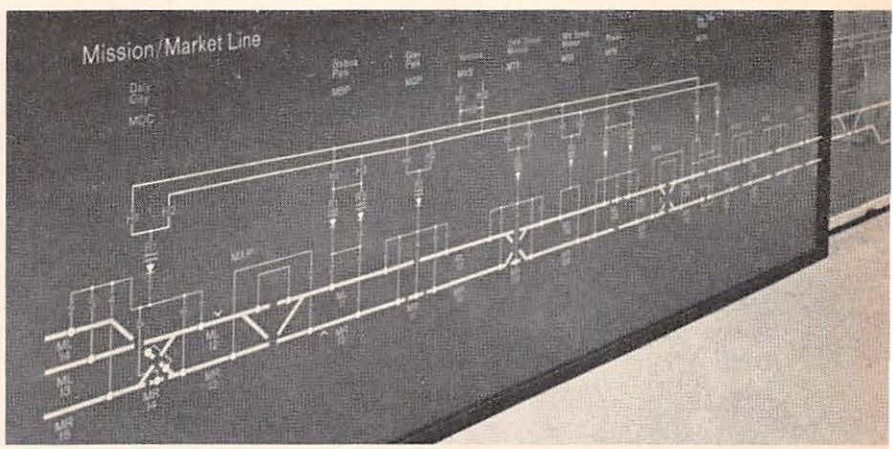


Locomotive-carried vane is part of check-in system at loading end.

RAILWAY CYBERNETICS:

BART: Controls are well along

The billion dollar San Francisco Bay Area Rapid Transit District project is at the halfway point. The train control equipment is being delivered on site by Westinghouse Electric Corp. On the following pages are articles describing the basic train control and operating system, and the simulation techniques developed for use by the central control computer.



A finished panel section of the BART display board which is being constructed by Transistor Electronics Corp.

BART CONTROLS

Computers will supervise automatic

J. W. Brownson and G. M. Thorne-Booth
Transportation Division
Westinghouse Electric Corporation

The San Francisco Bay Area Rapid Transit System will become a commuter railroad serving the city of San Francisco and the rapidly growing East Bay communities of the Bay Area. The initial system presently under construction will have four radial legs ranging from 14 to 23 miles in length and encompassing 70 route miles of wide gauge high speed electrified track.

The BART system will provide service at 90 second intervals during peak demand periods, extending to as long as 15 minute intervals during the low demand early morning hours. At no time will service be discontinued; by the use of carefully placed crossovers and the control of trains in a reverse running mode, maintenance work on the roadbed can be performed without serious disruption of the service. Use of the same run-around strategy will allow continued service in the event that a train becomes completely crippled, although serious degradation will inevitably occur if this unlikely event happens at a peak hour in a heavily travelled section of the line, such as the Trans Bay Tube.

In order to provide for high quality, reliable service BART has required a fully automated system of controls. Trains consisting of from 2 to 10 self propelled cars will be capable of operating at 80 miles per hour, accelerating to 50 mph in less than 20 seconds at acceleration and braking rates of about 3 mphps. An average system speed of more than 50 mph including stops will be accomplished. Dwell times at each of the 33 passenger stations will normally be controlled between 10 seconds and 30 seconds at peak demand. To assist passenger flow at the stations trains will be berthed to within ±5 feet around the centerline of the station, and destination lights will be illuminated at the anticipated door positions, the number of positions depending on the length of the incoming train.

Although BART will have an attendant onboard each train he will not have control of the train when operating in the automatic mode, his principal functions being those of an observer and communicator. He has the supervisory capability to override the automatic controls in one of two ways, first by commanding an emergency stop if he observes some unsafe condition not detected by the train protection system (e.g. a cow on the right-of-way), and secondly by switching to a manual mode of operation under train orders after a train protection stop caused by the failure of train or wayside equipment. In this manual mode the attendant controls the train under the direction of the system supervisor, with whom he is in contact by voice radio; the attendant may then move the train with visual guidance at a speed of no more than 25 mph—automatically limited by equipment design.

There will be two types of control systems employed on BART. One is a train protection system which will keep safe separation of trains, will prevent trains from exceeding the civil speed limits, and will control interlockings in a safe manner. The second system, the train operation system, will route trains throughout the property, will adjust the performance of trains so that the entire system will remain as stable as possible, and will implement such strategic and tactical plans as causing station run-through and turnback of trains during peak hours.

The train protection system is, of course, fail-safe and cannot be overruled by the train control system or by human error, with the sole exception of a train being handled in manual mode by an attendant: even in this event, no other train can be controlled in an unsafe way—an unsafe condition could only be caused by the attendant of the manually controlled train being unobservant or careless to a degree which is comparable to an engineman on a less sophisticated system passing a signal at red.

The train protection system is a local control function, being centered around each station. The protection system is that of traditional block control, wherein occupancy or unoccupancy of each block is determined and the position and locking state of each switch is determined. This information is used to control the speed commands transmitted to each train. On board each train, protection equipment is fitted to ensure that the speed of the train cannot exceed the commanded speed. By this procedure it is unnecessary for the train protection system to determine whether or not the train is obeying the speed commands; it is a sufficient condition to know that an unsafe speed cannot be transmitted and to know that whatever speed is commanded to the train, that speed cannot be exceeded.

Rather novel equipment has been developed to deal with severe requirements of BART; the use of short circuit bars to define the block limits and air cored transformers to launch power into the running rails are quite unique in train control design. The large number of different control speeds would be difficult to handle using conventional cab signalling techniques—a carrier amplitude modulated at different keying rates. Because of the problems of harmonic generation of the modulation frequencies and the contradictory requirements of quite fast response time and narrow bandwidths for noise rejection, it was decided to use serially coded information, modulating the carrier by frequency shift keying (FSK). Wide use has been made of semiconductors in failsafe circuitry, new techniques have been developed to ensure a restrictive output in the event of a component failure or combinations of component failure. The use of digital coding and the availability of inexpensive integrated circuits made it economic to use a time-division multiplex system, significantly reducing cabling and installation costs.

In contrast to the absolute requirements of the train

Editor's Note: Abstract of paper delivered at the IEEE/ASME Railroad Conference in Montreal, Quebec on April 15, 1969. Paper was recommended for presentation by the IEEE Land Transportation Committee.

train operations in bay area

protection system, the train operation system has incorporated in its structure three levels of priority; any of these levels may be invoked at any time to allow train movement even in the event of local or widespread equipment failure. These three levels are manual operation, automatic operation with maximum performance and supervisory operation through the central digital computer. As each higher level is invoked a faster, more stable system of train operation develops.

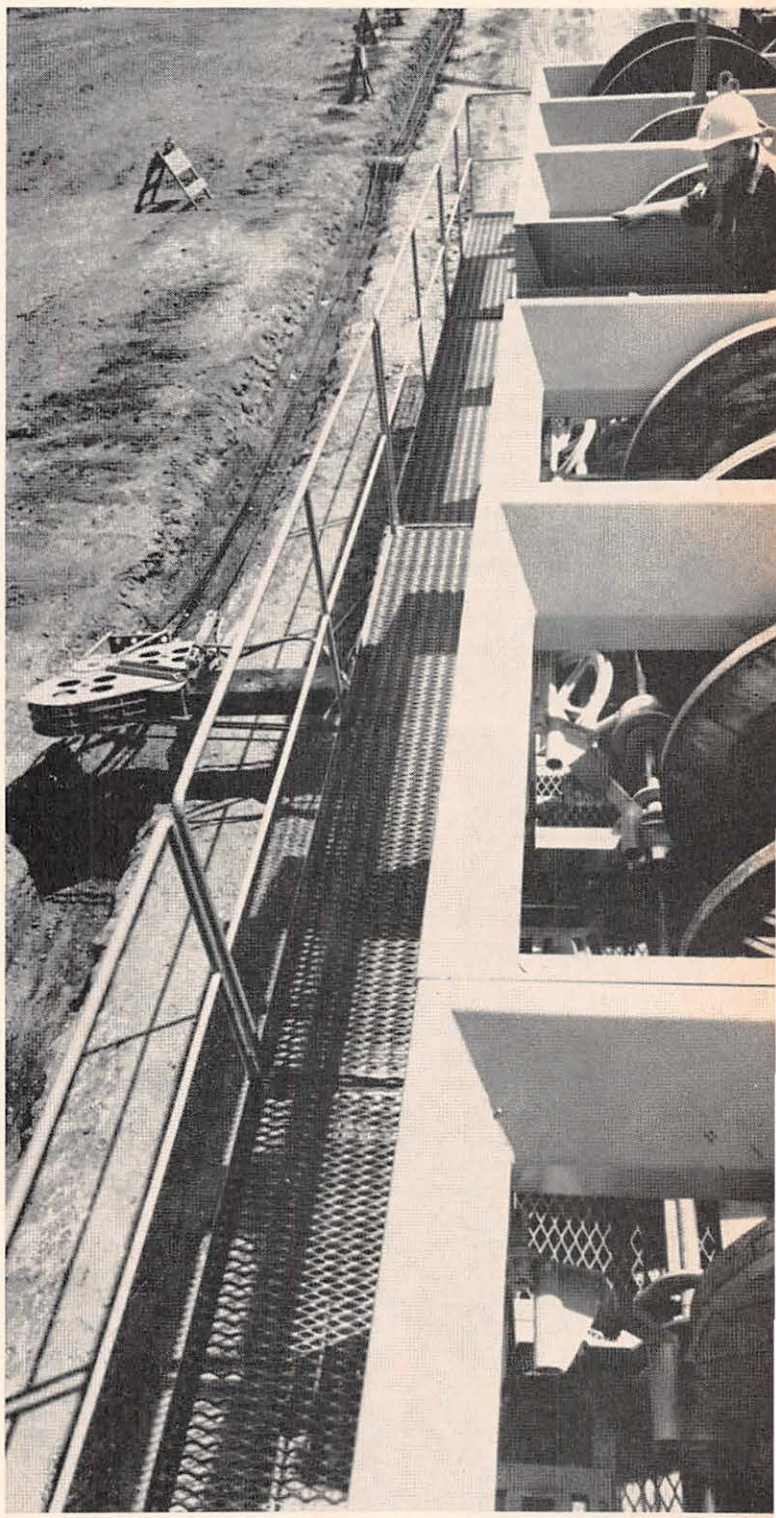
In the manual mode, routing of the trains is obtained by manual selection of the desired route. The route request may be made by telephone from the central office, or as a last resort by direct request from the train attendant when the train berths in a station. This stumbling procedure will only be required in the unlikely event that several different subsystems are simultaneously out of service; although serious queuing will occur over the network, all trains will run at maximum speed and acceleration levels once a route is cleared, subject only to the limitations of train protection.

For the next higher mode of operation, use is made of part of the train identification signal transmitted from each train as it approaches each station and interlocking. The train transmits its planned destination which is used to determine the route by automatic means and its train length, this information being used to light the correct destination sign providing information to passengers waiting on the platform. Once again all trains run at maximum speed and acceleration, and in this mode of operation the travel time for a single train with light passenger loading is a minimum.

The third mode of operation is the most sophisticated. The full train identification signal is used, consisting of length, destination and train number.

As in the second mode of operation, the length and destination signals are used to illuminate appropriate lights on the platform, and the destination signal is also used to determine the route automatically. However, in this case the train number and destination are also transmitted over a data link to the Central Office. If required, the Central Office can cancel the route request and substitute an alternate route request—perhaps because of track blockage or maintenance work. Central Office may also modify the dwell time in the station, and by the use of a performance modification data link to the train, can request a change in run time between the signaled station and the succeeding station. At the instant that the train starts to accelerate out of a station a message is sent via the data link to the Central Office computer; the computer calculates the optimum performance required from the train and transmits this requirement through the data link to the train before it has left the signaled station.

To be able to perform meaningful calculations, the computer monitors the performance of each train throughout the system. It is not necessary to monitor the performance in enormous detail, however, a number of critical status points have been chosen. The arrival time and departure time at each of the 33 stations and at each of



Special rail car is used for laying several control cables in trench alongside BART trackage.

BART CONTROLS

19 other locations at which a routing change or sequencing change may be made is transmitted to the computer, identifying the train by its unique train number and also stating the intended destination of the train. The strategy of control is indicated by the following:

At the beginning of each service day a theoretical schedule of arrival and departure times from these 52 locations is established for each of the 105 trains which may be operating on the BART system. As each train identifies itself its actual arrival time is compared to its theoretical arrival time. When this train berths at the next station this same comparison is made. A prediction is then made of the expected arrival of this train at the next station or at the route control point. At the expiration of the station dwell time, which is observed by the actual closing of the car doors, a new arrival time at the next key point is calculated. If this arrival time differs by more than ten seconds to the theoretical schedule arrival time, then an adjustment in the performance of that train is made.

These adjustments have been termed "Performance Modifications" and can achieve a 10% reduction or up to a 50% increase in travel time between adjacent key points. The ideal objective is to keep trains operating in the proper sequence and as close to the theoretical schedule as possible. If these "Performance Modification" adjustments are not sufficient to maintain these ideal objectives, then it is also possible to make adjustments to the station dwell times or to change the sequence of trains. If the latter approach is taken, attempts will still be made to sequence the dispatch of trains from the end-of-line terminals in the proper order.

Occasionally there will be poorly performing trains on the system which will call for different operating strategies to be implemented. The ideal strategy is to remove the poor performer from the system as quickly as possible and to substitute a good train. To do this may require as much as 30 minutes, during which time the whole system is slowly degrading. To reduce the effects of such an occurrence BART has placed its three storage yards near the end-of-line terminals and has included a third track at the one end-of-line terminal not near a storage yard.

Accomplishment of this stabilization control is done through a high speed digital process control computer system located at the operations control center in Oakland, California and a series of dedicated digital transmission data links to each of the 33 passenger stations and 3 storage yards. In the unlikely event that the computer system, the digital data links, or the private communications plans should fail to function, each train automatically operates as previously indicated.

No doubt a great deal of the system's success, at least in the public's eye, will be attributed to the use of two third generation Westinghouse Prodac 250 digital computers. Each of these computers has the capacity to control the complete BART network. Under normal circumstances one computer will be in control with the other computer available to take over control instantaneously if a failure occurs. The main communications link between the central computers and the transit system are the 45 digital transmission systems. Each DTS continuously transmits the status of field devices to the central computer. This status is then stored in the core memory of the computer in control. There are three major classifications of field status. They are Train Control Status, Electrification Status, and Support Facilities Status. Corresponding to each of these major areas of field status is a program in the Central Computer. Each of these programs will periodically check for changes in status. Each detected change will then be diagnosed as a requested or normal action or an abnormal action (alarm conditions). Examples of some of the functions involved in each of these major areas follow:

Train Control Status

- Correct tracking of trains throughout the network.
- Verification of routing of trains.
- Detection of arrival and/or departure of trains at stations.
- Detection of arrival and/or departure of trains at inlockings.
- Verification of correct operation of interlocking equipment.

Electrification Status.

- Monitor of High Voltage Breakers.
- Monitor of Low Voltage Breakers.
- Monitor of Contact Rails.

Support Facilities Status

- Monitor of line fans, ventilation dampers and sump pumps.
- Monitor of emergency telephones.
- Monitor of alarms.

From each of these three programs alarm conditions are passed on to the System Alarm Program. It is the function of this program to annunciate on a priority basis the devices in alarm. Changing status is also transferred to Display Board Control program. This program then updates the indications on the display boards as requested by the operations personnel or alarm conditions. The Train Control Status is diagnosed by the Train Detection Program. Another function of this program is to provide detected train information to the System Performance Monitor and Control Program. As mentioned before, prior to actual dispatch of train(s) a theoretical schedule will be generated for the train. The System Performance Monitor & Control Program will then attempt to run trains to their theoretical schedule by adjusting train performance levels and dwell times.

There are a number of support programs used in the Central Control Program. Of the over 20 separate programs which the computer uses a few may be of interest. A short abstract is given of each.

DIGITAL TELEMETRY INPUT PROGRAM: This program provides for inputting of data from 45 Digital Telemetry Stations on the BART system. On this project, the DTS provides the only means of inputting on-line process indications to the computer. Each DTS has anywhere from one to twenty 14 bit (parallel) words of data and 5 bits (parallel) of data address in-putted to the computer at the rate of 23 ms per word. Thus, depending upon the word size of a terminal a word may appear to the computer anywhere from 2 to 40 times per second.

TRAIN DETECTION PROGRAM: The Train Detection Program examines incoming data associated with train control. Data on train performance and interlocking op-

Computer checks 105 trains at 52 points on 70 miles of line.

eration is accumulated for use by the operator and other programs. Invalid conditions are alarmed via the display boards and typewriters. The program is organized such that it will ignore information not associated with train control or not needed to perform its functions. The program will be entered every ½ second, checking for changes in the DTS data associated with its assigned functions. When a change is detected, the function is performed and the scan for more changes continued. Arrival and departure times for trains at stations and interlockings are stored for use by system history and performance monitor programs. Routing is monitored and invalid routes alarmed and canceled.

INTERLOCKING MONITOR: The Interlocking Monitor checks the operation of all interlockings on the system. Its function is to compare route request to switch alignment and gate operation. The program will have the capability to examine all route requests possible and alarm malfunctions. Improper operation will cause a route cancel to be sent in the automatic mode of operation. Alarms will be given in all modes of operation.

TRAIN ALARMS: This program provides for detection of Train Control Alarm Conditions. The various types of alarms are Rock Fall, Foreign Vehicle, and Distorted Track.

BART DISPLAY BOARD PROGRAM: This program controls the operation of the three BART display boards that gives the supervisor a visual picture of the state of devices and alarmed areas. The program receives (rail status, platform and interlocking status) information from the train detection program and from the Electrification Monitor, Support Facilities Monitor, Systems Alarms and the Interlocking Monitor.

THEORETICAL SCHEDULE PROGRAM: This program is used to calculate a theoretical schedule for trains, on the BART System. At some time prior to dispatch time the schedule that a train will attempt to follow is computed. This program makes use of the various run times between stations to compute the arrival, dwell, and departure times for trains.

CAR INVENTORY CONTROL PROGRAM: This program provides for gathering and correlating car operating hours, car mileage, car location and availability to train consists on the BART system.

REVISE TRAIN DISPATCH DATA: This program is used to revise, add, or cancel train dispatches on the BART system. The train dispatch data is stored in bulk memory and updated as requested by the operations supervisor. A keyboard provides the means by which to enter the new data.

In order to use all these programs the computer requires a central processing unit of about 24K core memory in addition to the bulk storage on random access disc files of 375K.

BART DISPLAY PANEL AND INTERFACE: Besides the actual running of the trains, the most glamorous part of BART to the man on the street, will be the system display board.

The BART display panel monitors three sub-systems of the overall BART system; Train Control, Electrification and Train Support Facilities. The panel is 88 feet long and is divided into two 36 ft. and one 16 ft. sections, each of which is primarily designed to monitor one of the aforementioned subsystems.

Subsystem information is displayed on the panel by the switching of lights to either an ON state, an OFF state or a FLASHING state. The ON or OFF state usually indicates normal operation while the FLASHING state reflects abnormal operation. A 14 bit binary word from the computer to the display panel interface circuit results in the addressing and "turning on" of a single light.

The train control display board will be similar to the

Dual computers to supervise, control BART operations.

standard CTC board with the exception that there will be no switches on the board. Station names and interlocking numbers will be continously illuminated.

Terminal zone and transfer track ready indications will be illuminated when a train is ready and extinguished when the train departs. Platform lights at each station will operate in a similar manner.

Interlocking gates for entrance and exit will be lighted amber if the route has been requested and the gates are closed, lighted green is route is aligned, locked and gates open, and lighted white if the track is occupied or unoccupied with no request present.

In order to control the display panel over 6,000 independent lamp drivers are needed (expandable to 10,000) which presently have the capability of driving over 46,000 indicator lamps.

There are three areas of train control which may be of interest that have not been described before. These are train identification, performance modification, and station run through.

STATION RUN THROUGH: If, for some reason it is desired that a train should skip a station, the operations supervisor will notify the local line supervision at the particular station via the digital transmission system (DTS). The central computer will have made the recommendation through the information fed to it by the DTS system. The particular train approaching the station is known from the ID system.

In order to activate a station run through, the local line supervision turns off the wayside program stop transmitter. Receiving this signal causes a more restrictive speed command, thus implementing a program stop. The absence of the signal allows the train to proceed as governed by the conventional block signaling. A station run through is thus accomplished.

TRAIN IDENTIFICATION: The Train Identification System required for BART provides a data communication link and data storage between the ground equipment and the train carried equipment.

In the present system, two full transmissions of data are made, one between the train and the wayside equipment, the other from the wayside equipment to the train. Data is transmitted using a highly reliable communication modem which codes the serial data in frequency shift keying. These data links provide the following information: (a) Identification of the train including serial number, destination, and length; (b) Performance modification of the trains; (c) Door opening and closing operation; (d) Performance modification data to the speed maintaining equipment.

The data for train ID is supplied from Central Line Supervision (CLS) via Local Line Supervision (LLS), station or Yard Control. At remote points data is relayed to the train ID wayside transmitter via a multiplex data link (part of interface equipment). At other locations, such as, stations and yards, the data is relayed via hard wire links.

BART CONTROLS

The vehicle equipment used consists of a transmitter, receiver, registers for performance modification, serial number, destination and length.

The wayside equipment is composed of a receiver and a transmitter. These are interfaced to the various data links.

A typical sequence of operation when a train enters the station is given below:

(1) A train enters the station block with its transmitter continuously transmitting data for destination, serial number and length via a frequency shift keyed audio tone.

(2) After the train has executed a programmed stop it detects the wayside transmitter signal which instructs the train to open the doors. The train opens its doors, transmits a signal to the wayside and clears the train-carried performance modification register.

(3) At the end of the dwell time, which has been timed by the local line supervision, the programmed stop transmitter shuts down and a door close signal is sent to the train thus returning the train control to the speed maintaining equipment.

(4) As the train starts, it again sends out its ID signal. This is used to inform the computer that the train is leaving and requests an updating of the performance modification information. The calculated updating is transmitted to the train before it leaves the platform.

At certain locations called terminal zones the ID information may be updated as outlined below.

At divergences or convergences, the ID will be read by the ID reader located on the main line approach to the divergency or convergence. This data will be stored in buffer registers until the route request for that train is sent to the interlocking. At that time the ID location, train destination and train serial number is transmitted to central control via the DTS system.

At terminal zones not located in a station zone the initial information will be sent to central control after the train has been reversed and a train ready signal is sent to local control. The initial information transmitted to central control will be the train ready signal. Upon receipt of the train ready signal the computer will send out a new destination to the terminal zone ID transmitter.

After the new destination has been sent to the train from central, the train serial number and destination will be transmitted back to central for verification. If central control cannot verify the ID as being correct, it will retransmit the new destination again and the above sequence will be repeated. The sequence will be repeated a third time if the second attempt fails. If the ID is still unverified after three tries, the computer will annunciate this as an alarm condition at central control.

The train ID must now be manually set by the train attendant per radioed instructions from the operations supervisor at central control. Manual dispatch of the train will be made from the nearest yard.

If the ID can be verified by either method mentioned above, the computer will send a dispatch signal 10 seconds prior to the scheduled departure time of the train. This time delay will allow for route alignment and for the destination signs to be illuminated at the first station enroute when that station is located near the terminal zone.

After verification of the new train ID, the computer will send the dispatch signal at a sufficient time prior to the train departure to allow for a new destination sign to be illuminated, arriving passengers to board the train, and the route aligned for departure.

At transfer tracks (yards) the train ready signal, ID location tag, and train length will be transmitted to the yard master control console where it will transfer the information to central control. The computer will then transmit a new ID consisting of train length, destination and serial number to the train. The subsequent procedure as outlined above will be followed to verify the correct ID. Upon verification of the proper ID, the train dispatch signal will be sent 10 seconds prior to the scheduled departure.

The installation of all of the Central Office display equipment is complete and being checked out. The installation of data links, radio communications station logic, control and protection functions has been started.

Transit simulation works at BART

By A. F. Harsch, Consultant
Computer Control Systems
Westinghouse Information Systems Laboratory
Westinghouse Electric Corporation

The main control problem, during the design and construction of a computer-controlled urban rapid transit system, is that of devising the control strategy logic which will maintain normal service or minimize the delays while satisfying the required standards of passenger comfort and convenience.

Passenger requirements dictate a uniform time of headway between successive trains passing through any station in the same direction and that no train should be forced to stop anywhere on the system. It may be desirable at times to slow down certain trains in order to reduce the extended gap ahead of a delayed train or to extend the reduced gap behind a delayed train. Other more drastic measures may be necessary such as running a train through a station in order that it can reduce the extended gap ahead and extend the reduced gap behind.

Figure 1 shows a typical computer-controlled mass transit system where the individual trains are in communication with the computer only in the vicinity of passenger stations and interlockings. As a redundancy to computer control of the train, each station is provided with a local programming device which can give the train a command to dwell at a station for a predetermined interval and to travel to the next station at a predetermined speed. This local program control is *not* independent of the computer control but operates only when not "overridden" by computer control. A signal block control system operates completely independent of the computer control and the local redundant program control to lower speed or stop the train for safety purposes, such as when two trains become too close.

The computer receives the following data: identification number of trains at ingress-egress points of a route; presence of a train (without identification) at a station or interlocking; train with its doors open; and departure of a train from a station. At the same time the computer sends out the following instructions: corrective speed command

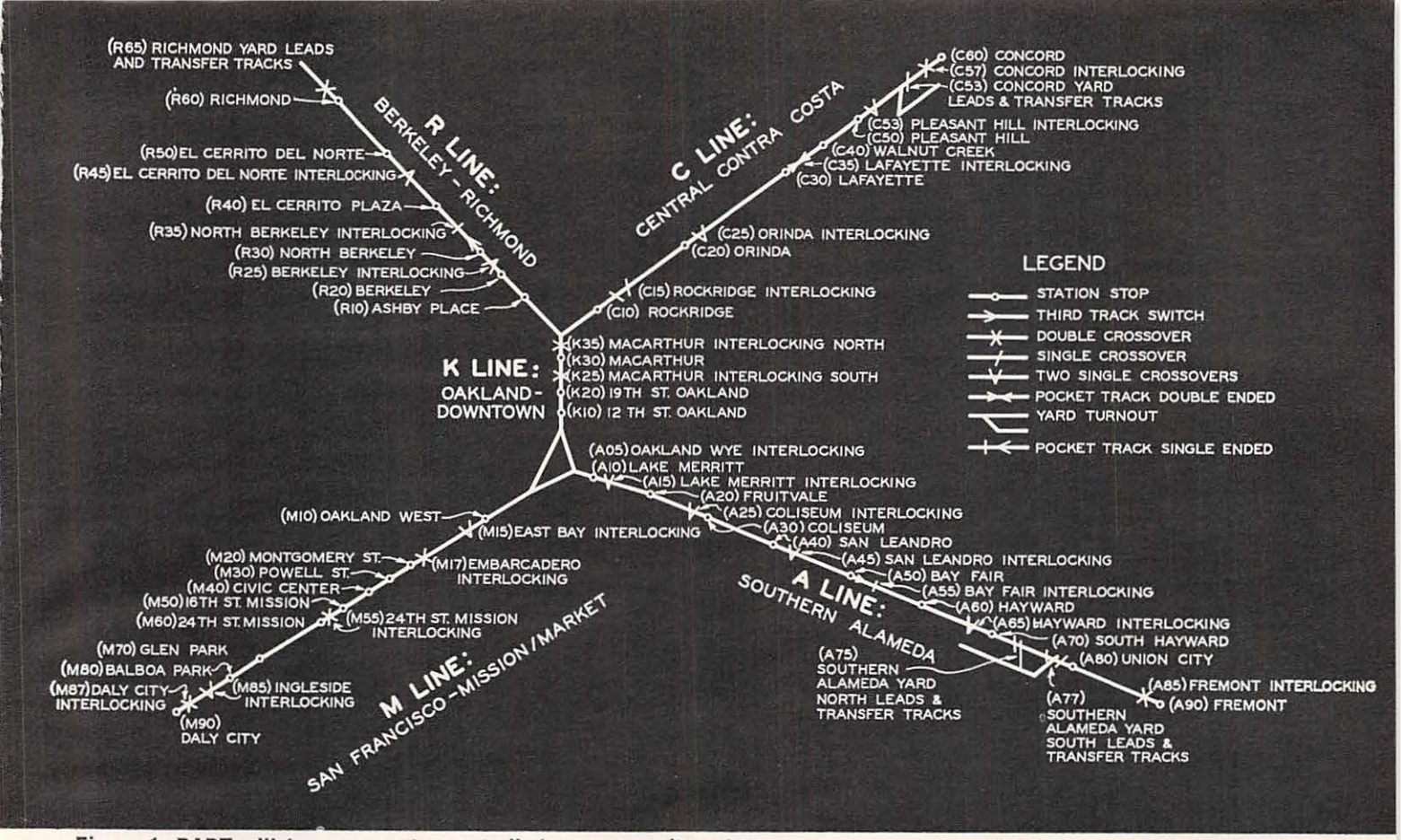


Figure 1: BART will be a computer-controlled mass transit system.

to a train departing a station; and hold and release signals to override local programming devices which cause trains to dwell for a predetermined interval. The only prior art is the practice of "people operated" passenger railways. Train crewmen and station attendents use telephone or cab radio communication to make corrective adjustments. These were limited to crude control strategies.

Digital simulation techniques have been used to determine the control strategy logic that will maintain normal service under small random variations or if this is not possible, minimize the delays.

The proposed philosophy of how the control strategy logic maintains the current operating schedule is fairly simple. It makes use of two schedules, a theoretical (or required) schedule which is calculated from the current system operating schedule (supplied by the rapid transit system operating personnel) plus or minus any system offset, and a modified schedule which originally starts out as being the same as the theoretical schedule. It is required that the theoretical schedule be calculated 10-15 minutes before dispatch time or possibly earlier if the turnaround time is longer than 15 minutes. The modified schedule shall at this time be made the same as the theoretical schedule.

The control strategy logic has the task of determining which corrective strategy will result in the most favorable consequences. The most favorable consequence is defined to mean that a uniform gap (time between a train departing a station and the following one arriving at the station) is more important than the theoretical schedule arrival and/or departure times. This means possibly slowing down trains ahead of a delayed train to make the gap more uniform. To bring the system back up to the theoretical schedule, all trains are dispatched from a turnback at the theoretical schedule dispatch time if possible. This probably will not be possible during rush hours but on medium-peak and off-peak hours, it will enable the system to get back to the theoretical schedule.

The two schedules are used in the following manner: trains will run to the modified schedule (which starts out being the same as the theoretical schedule); train performance is based on the theoretical schedule. If a train is to be slowed down or otherwise disturbed not due to its own fault, the theoretical schedule is changed along with the modified schedule in order not to give this train a bad performance index. Trains are dispatched from the modified schedule (normally the same as the theoretical schedule). If the train can't possibly meet the theoretical schedule dispatch time after taking into account the minimum turnaround time, the dispatch time in the modified schedule is revised. In other words, a train is dispatched as soon as possible after entering the turnback but not sooner than the theoretical schedule dispatch time. Thus when a train is dispatched, except for possibly the dispatch time, the rest of the modified schedule for this train is the same as the theoretical schedule. If the train cannot get to the next station, convergence or turnback on time, this arrival time and any intermediate interlocking arrival and departure times are changed in the modified schedule in order to have the best estimate of arrival times. Also if the delay is long enough, the gap is distributed among the trains ahead of the delayed train by revising the appropriate modified and theoretical schedules. In effect the trains will probably be slowed down on each run (especially during rush hours) but they will now be dispatched on time (according to the theoretical schedule) if possible at the next turnback.

The complex interrelationships between the operation of any one train on the transit system and the positions, performances and abnormalities of the other trains in revenue service make it difficult to draw conventional flow charts that take into account all possible conditions. A decision table approach makes it possible to make changes to the logic without upsetting the main program. A decision table comprises three parts: 1) All the variables that influence any decision, 2) Actions which are to be

BART CONTROLS

carried out once the decision has been made, and 3) Rules that link the actions and conditions together by showing the required states of each variable which have to be satisfied for any decision. Because of limited experience in predicting the strategies that have to be applied when certain abnormal conditions arise, it is inevitable that there would otherwise have to be much modification and readjustment of flow chart details in this particular area.

The control strategy logic has been broken down into two main parts: run train to schedule, and modify train schedules. The first part (run train to schedule) essentially tries to maintain the modified schedule by adjusting performance level and station dwell time. In addition it checks the dispatch time of a train coming into a turnback and revises this if necessary. Under normal operating conditions with small random variations, this part of the control strategy logic should maintain the current operating schedule. The second part of the control strategy logic (modify train schedules) essentially computes a performance index of each train of the entire system, and changes the modified and theoretical schedules as necessary in order to apply additional strategies. These additional control strategies could include distributing the extended gap ahead of a delayed train among its leaders, offsetting the system and causing a delayed train to run through a station. In essence, this second part uses decision table logic and only gets a match or hit to apply an additional strategy when something abnormal occurs. Provided the schedules are realistic and the equipment does not malfunction, this second part of the control strategy logic will not find it necessary to apply any additional strategies over and above what was applied in the first part of the control strategy logic.

The criterion of performance of the entire system should be based on passenger satisfaction or some "service quotient". However, since the theoretical train schedules are presumably designed to optimize this passenger flow, the performance of the entire system can more readily be judged by measuring the total error between the actual and desired train schedule. It is assumed that the transit system will provide at least a framework of each train's dispatch time, route, and of all critical point scheduled arrival times in between the origin and destination on each trip. Note that these could include intermediate stations as well as origins, destinations and converging interlockings if the transit system considered it to be a location at which they would like the train to be on time. Corrective strategies would endeavor to keep trains on time at critical points and would allow some latitude at other points. However, if this is not possible, then the next objective would be to try to keep the correct train sequencing, and lastly if neither strategy is practical, then although nothing more can be done at this particular critical point, the strategies will try to remedy the situation by the following critical point.

The train performance index (PI) is a measure of how close the train actually comes to its target (theoretical schedule). For example, if a train is dispatched a few minutes late according to its original schedule as supplied by the transit system, then if there were no headway considerations its target would be one and the same as the original schedule and the train would have a bad PI on dispatch and at all subsequent points until it eventually got back on schedule. Only if a completely new theoretical schedule were generated would it be possible to avoid these bad PI values for a late dispatched train.

It is here proposed that a measure of system performance can be obtained by computing every t minutes (where t=2 minutes on peak to say 5 minutes off peak). The following formula is used:

ERROR = A (average PI of all trains in revenue service)
+ B (deviation of all PI's about average PI)
+ C (rate of change of average PI)

where A, B, and C are weighting factors which may vary between peak and off-peak hours, and where the rate of change is positive if the average PI has increased since it was last computed t minutes earlier. Note that the ERROR will drop if the entire system schedules are offset because the train PI's will instantly improve when each train finds itself closer to its new target.

There are basically two types of strategies:

(1.) Strategies to reduce ERROR for the entire system such as:

(A) Offset entire system theoretical schedules.

(B) Offset theoretical schedules of train in one section only.

(C) Remove faulty trains from system.

(D) Revise train destinations.

(2) Strategies to reduce PI values and maintain correct sequence for individual trains such as:

(A) Delay or speed up trains relative to their schedule.

(B) Distributing headways ahead of a delayed train.

(C) Distributing headways behind a delayed train.

(D) Revise sequence at interlockings.

(E) Execute station run-through.

While system strategies are reviewed every t minutes train strategies are selected every time a train arrives at or departs from a control location and it is for this latter purpose that the decision table approach was decided upon.

Modeling and off-line simulation of a rapid transit system are of great importance because they permit the study of the effects of various systems decisions or choices (control strategies). A model can be defined as being a representation of a system or part of a system in a mathematical, tabular or physical form suitable for demonstrating the way a system behaves or may be considered to behave. The model should show the effects of those factors which are significant for the purposes being considered. It should also describe the essential inputs, outputs, and internal characteristics, as well as provide an indication of environmental conditions similar to those of the actual equipment.

Simulation on the other hand involves subjecting this model to various inputs and/or environmental situations in such a way as to explore the nature of the results which might be obtained by the actual system when experiencing these sorts of inputs and/or environmental conditions. This exploring of the nature of the results of a simulation can be achieved by the relative weighting of objectives. Thus, given the several bases of judging the value of a system and the relative weights by categories, the methods of trade-offs, static optimization, dynamic optimization and linear programming could be used to solve the problem of affecting the compromises. If the results are not satisfactory, inputs can be changed and another simulation performed. Using digital computers, this automatic exploring of the nature of the results could be incorporated in a simulation program which would now give the best possible results among the choices programmed.

Modeling of a rapid transit system for the purpose of determining control strategies needed to maintain a predetermined schedule or, if this is not possible, to minimize delays need not be elaborate or mathematical in nature. The central control computer obtains information about the rapid transit system from only "n" discrete locations in the system. Of these, performance adjustments can be applied at only "m" discrete locations (m n) in the system.

TABLE A (At Start of Simulation - 130700 Hours)
NEXT SIX CRITICAL POINT
NUMBERS AND THEORETICAL SCHEUDLE TIMES

TRAIN ID	IN REV. SERVICE	FIRST	SECOND	THIRD	FOURTH	FIFTH	SIXTH
41	Yes	6 132353	5 132500	4 134343	2 134853	1 135100	3 135400
169	Yes	3 131010	6 132853	5 133000	4 134843	2 135343	1 135800
323	No	1 131000	3 131510	6 133353	5 135200	4 135200	2 135700

TABLE B
ORDERED REQUIRED SCHEDULE TIMES AND PREVIOUS CRITICAL POINT FOR TRAINS DUE AT EACH CRITICAL POINT

	CP1			CP 2			CP 3			CP 4			CP 5			CP 6	
ID	TIME	FROM	ID	TIME	FROM	ID	TIME	FROM	ID	TIME	FROM	ID	TIME	FROM	ID	TIME	FROM
323	131000	0	41	134853	4	169	131010	1	41	134343	5	41	132500	6	41	132353	3
			169	135353	6	323	131510	1	169	134843	5	169	3000	6	169	132853	3
			323	135853	4				323	135343	5	323	3500	6	323	133353	3

ID is identification
CP is critical point

TABLE C

LATEST PARTICULARS OF ALL TRAINS IN REVENUE SERVICE

TRAIN ID	MALFUNCTION CODE	NO.	LAST CP ACTUAL TIME	NEXT CP PRED TIME	TRAIN SEQUENCE	LAST PRED PI	LAST CL
41	0	3	130510	132353	0	0	13
169	0	1	130500	131010	0	0	4

PRED is Predetermined
CL is Control Location
PI is Performance Level

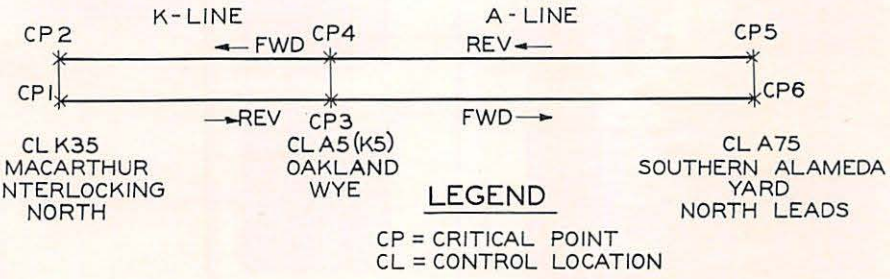
TABLE D

CURRENT TRAIN PI VALUES DURING LAST FOUR SYSTEM ERROR COMPUTATIONS

TRAIN ID	PI VALUES AT TIME T	T-t	T-2t	T-3t
41	0	0	0	0
169	0	0	0	0

T is last time
t is interval between computations

Decision table logic was used to set up the above tables A through D. These tables are generated at the start of simulation of train running (see top right box in simplified flow chart on next page). Critical point diagram is at right.



The central control computer has no control of the system other than at these discrete locations and no knowledge of what is actually going on in the system between these locations. This is analogous to a series of batch processes where calculations and adjustments are made at the start of a batch process (i.e. leaving a station zone) to obtain the correct result at the end of the batch process (i.e. arriving at the next station zone). To make matters simpler, a train covers the distance from one of the "n" discrete locations to another in only one of "j" nominal run times and dwells in stations only in increments of "i" seconds. Thus the model of the rapid transit system for the purpose of determining control strategies is essentially a tabular representation of the system at the "n" discrete locations and the associated logic to set up and use these tables.

The rapid transit system simulation program for control strategy logic determination and check-out is essentially an event-oriented simulation that runs faster than real time because events are allowed to happen as fast as possible. This simulation program for determining and checking out the logic for the control strategies has evolved into four distinct parts as follows:

(1) Setting up the system. In essence this part reads in the system data for the rapid transit system being simulated and sets up the tabular representation of the system at the "n" discrete control locations.

(2) Initializing the system. This is necessary to establish a starting point for the simulation.

(3) What event occurs next. This is the heart of the event-based simulation which features a new approach on how to specify what events occur. Instead of reading in a stack of cards containing each event in the order of occurrence, an offset from normal table is read into the computer. The logic is such that an event will occur as predicted plus a random variation unless there is an offset associated with that train at that control location which makes the event occur earlier or later than normal.

(4) Control strategy logic. This consists of two parts corresponding to run train to schedule and modify train schedules described earlier. The part corresponding to modify train schedules is the real reason for the simulation. This is the experimental part employing decision table logic that is tested in order to come up with the proper operational strategies to minimize delays when performance level adjustments and dwell time changes alone cannot maintain the schedule. In addition, the part corresponding to run train to schedule is altered from previous thinking because of pitfalls encountered with the logic.

The first part of the strategy selection via decision table logic sets up Tables A through D as shown.

Six critical points (or CP's) have been chosen (see drawing), but more could be added. Note that each

BART CONTROLS

CP could have two previous CP's (i.e., a convergence) or two next CP's (i.e., a divergence). A train must enter or leave revenue service at a critical point. The function of the remaining tables can be ascertained by inspection which shows the entries at the beginning of a test simulation run at 130,700 hours. At this time, train 41 was traveling in the forward direction on the A line, train 169 was traveling in the reverse direction on the K line and train 323 was waiting to enter revenue service at CP 1. These tables are updated whenever a train arrives at a CP which makes it possible for the program to take an over-all view of the system. When the entire multiline system is simulated, they will play a more important role in sequencing, assignment of trains to scheduled runs and in the reversing of destinations.

Figure 2 shows the relationship between the strategy selection via decision table logic and the rest of the simulation program. Without the two interfaces shown dotted, the main program would only be able to follow the run to schedule strategy where the schedule would be the same as the original theoretical schedule. Whenever an event occurs in the main simulation at time "T", full particulars of the type of event, the control location and the number of seconds between the train's actual and theoretical schedules, etc., is sent to the strategy selection via decision logic portion of the program. From this information together with the information stored in Tables A through D, a key word is generated by the logic. Any invalid or redundant variables are eliminated from the key word by a corresponding key mask. Normally the combined key word and key mask will match a rule and rule mask combination in a decision table which may comprise several hundred rules. The action to be taken following a hit might vary from a simple confirmation that the latest schedule is satisfactory, to some of the more involved

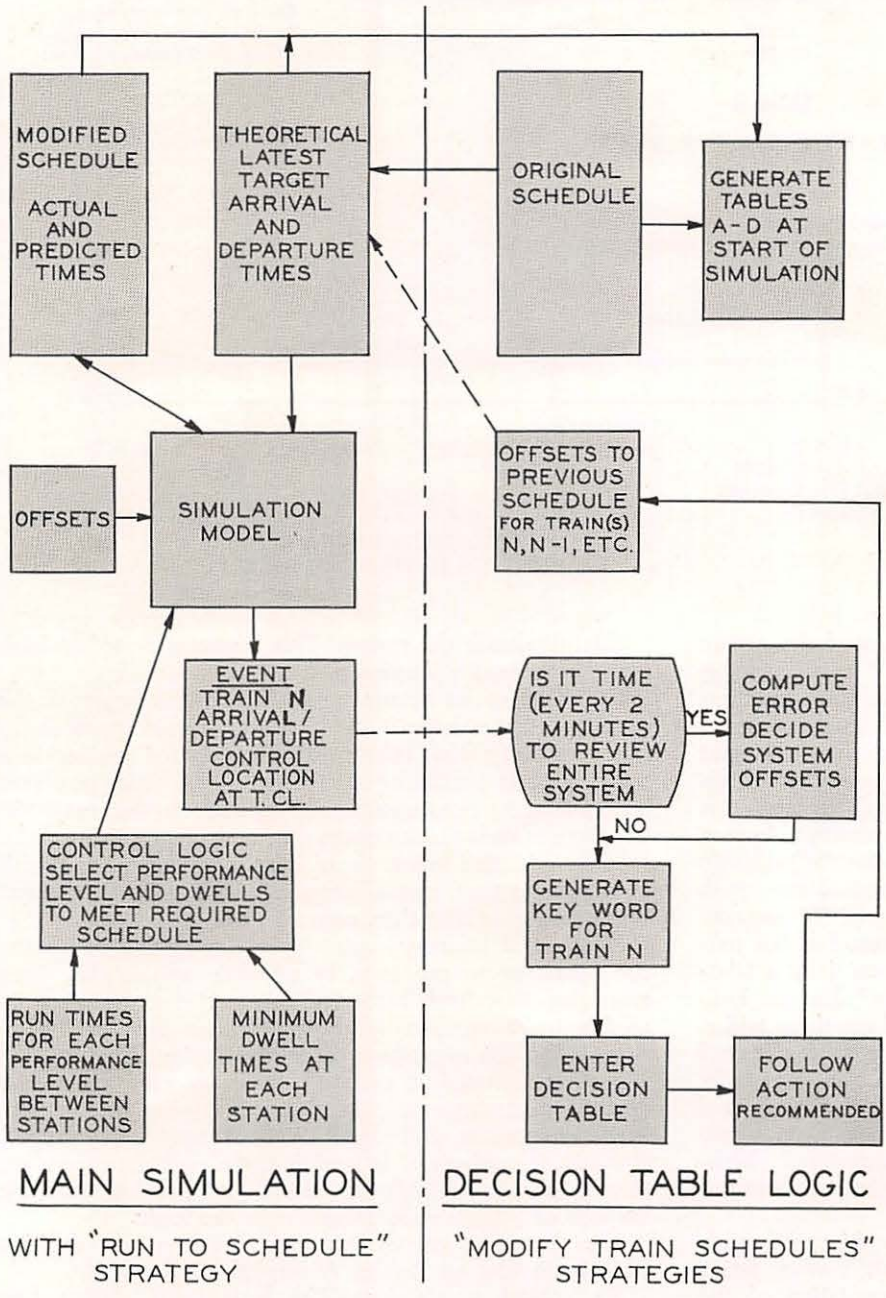

MODIFIED SCHEDULE
ACTUAL AND PREDICTED TIMES
THEORETICAL LATEST TARGET ARRIVAL AND DEPARTURE TIMES
ORIGINAL SCHEDULE
GENERATE TABLES A-D AT START OF SIMULATION
OFFSETS
SIMULATION MODEL
OFFSETS TO PREVIOUS SCHEDULE FOR TRAIN(S) N, N-1, ETC.
EVENT TRAIN N ARRIVAL / DEPARTURE CONTROL LOCATION AT T. CL.
IS IT TIME (EVERY 2 MINUTES) TO REVIEW ENTIRE SYSTEM
YES
COMPUTE ERROR DECIDE SYSTEM OFFSETS
NO
CONTROL LOGIC SELECT PERFORMANCE LEVEL AND DWELLS TO MEET REQUIRED SCHEDULE
GENERATE KEY WORD FOR TRAIN N
RUN TIMES FOR EACH PERFORMANCE LEVEL BETWEEN STATIONS
MINIMUM DWELL TIMES AT EACH STATION
ENTER DECISION TABLE
FOLLOW ACTION RECOMMENDED
MAIN SIMULATION
WITH "RUN TO SCHEDULE" STRATEGY
DECISION TABLE LOGIC
"MODIFY TRAIN SCHEDULES" STRATEGIES

Figure 2 shows main simulation and decision table logic flows.

	Magnitude of Delay (%)	Frequency of Occurance (%)
SET 1		
	0	64
	5	8
	10	7
	15	6
	20	5
	25	4
	30	3
	35	2
	40	1
SET 2		
	0	84
	2	4
	5	3
	7	3
	10	2
	12	2
	15	1
	17	1
	20	0
SET 3		
	0	100
SET 4		
	50	100
SET 5		
	75	100

Figure 3 shows distributions of random variations used in the simulation to provide for realtime contingencies.

WISL service to users

Westinghouse Information Systems Laboratory has 56 computer centers and 94 computers with a staff of over 200 persons to provide a variety of computing services. Services available include computer time-sharing, numerical control machine tool programming, automated engineering information systems, management information systems, computer systems utilization, computer-aided problem solving and engineering analysis.

```
TRAIN 105 DEPARTED FROM A40 AT 130223
   TRAIN NOW RUNNING AT PERFORMANCE LEVEL 1
   TRAIN PREDICTED TO ARRIVE AT A30 AT 130403
   TRAIN WILL HAVE A RANDOM DELAY OF 10 SECONDS
   TRAIN BEHIND SCHEDULE BY 152 SECONDS
   DISTRIBUTE HEADWAYS OF TRAINS AHEAD OF THIS TRAIN
   AT CRITICAL POINT 4 OFFSET TRAIN 104 BY 90 SECONDS
   OFFSET THEORETICAL SCHEDULE OF TRAIN 104 IMMEDIATELY BY 101 SECONDS

TRAIN 306 ARRIVED AT M55 at 130231
TRAIN 306 DEPARTED FROM M55 at 130231
   TRAIN CONTINUES RUNNING AT PERFORMANCE LEVEL 2
   TRAIN PREDICTED TO ARRIVE AT M50 AT 130315
   TRAIN BEHIND SCHEDULE BY -0 SECONDS
   CONTINUE WITH EXISTING SCHEDULE
```

Figure 4 shows a portion of the printout of a simulation run.

strategies listed in the specification of the system.

One good way to use the simulation program is to set up a simple two line system with only a few entries in the decision table. Even before the model was expanded to the multiline system or improved to allow for the effect of train headways on minimum dwells and other refinements, it was possible to develop a useable decision table by means of simulation runs. The disturbance offsets included in the input data should contain the most probable number of offsets of each magnitude. On the initial runs the maximum offset could be limited to approximately half the average headway time. Since the initial decision table only had a few entries, the program first tried the simple strategy of running to modified schedule whenever there is no match.

ERROR was computed every two minutes and as long as it remained below the threshold value it was obvious that this strategy was satisfactory. A subroutine would then convert the large number of unmatched key words generated during the simulation into a smaller number of rules which could be added to the decision table. This procedure was repeated with a higher maximum offset limit until ERROR became excessive. Additional simulations were then run so that another strategy would be applied to any event having an unmatched key word. The next strategy might be distributing headways and hopefully it would be effective in reducing ERROR sufficiently so that new rules for this strategy could be found. As offsets and other system abnormalities were increased, more advanced strategies were tried and the decision table was gradually built up to encompass all likely eventualities.

At the same time that the simulation runs were made as described above, the control strategy logic for running trains to schedule using performance level (PS) adjustment and dwell time changes were tested under various operating conditions. Certain limitations were encountered with this part of the logic, so changes had to be made.

One of the features of this rapid transit system simulation program is the ability to have a number of different random variations as disturbances to this system. In this manner, hopefully the real life system was more realistically described. Essentially all of the simulation runs were made with the five sets of random variations as shown in Figure 3. The simulation runs showed that once a train was slowed down or delayed and using the SET 1 random variations, the train never caught up again. This was due to the fact that the schedules used in the simulation were based on normal run times which were maximum run times plus 10% while SET 1 random variations gives a 36% chance of a delay to occur and a weighted average delay of 22.5%. This in effect gives an average delay of approximately 8% for every event that occurs. With only a 10% margin in run times to catch up and increased minimum dwell times, the train never has a chance to get back to the theoretical schedule before it reaches the turnback.

If on the real-life rapid transit system, the magnitude and frequency of random variations are on the order of SET 1 random variations and if the schedules are based on the normal run times, a train that has an abnormal delay will never get to its destination on time. In most of the simulation runs, SET 2 random variations were used (one-half the magnitude and one-half the frequency of SET 1 random variations). SET 3 random variations were not used very much except for some comparisons as it was felt that this did not describe the real life system.

Other disturbance types were put into the system to try to simulate abnormal delays. Such disturbances consisted of choosing 30-second or 150-second delays for certain trains departing from certain stations. This allowed us to determine what the best rules in the decision table would be when abnormal conditions occurred. Other disturbances such as SET 4 and SET 5 random variations shown in Figure 3 were used to determnie the effect of offsetting the entire system in time.

The simulation runs were made using five-minute and 2½-minute headways on a two-line system, and at five-minute headways using a three-line system. These simulation runs were carried out for 25-minute periods of simulated time. Trains were dispatched from turnbacks at approximately 5-minute intervals. A number of things were determined from these simulation runs. A minimum dwell time calculation was formulated and tested because the early simulation runs showed a need for this. A method of selecting a planned performance level upon a station arrival and the method of adjusting the dwell time up or down from scheduled dwell was formulated and tested because of instances where simpler methods gave inconsistent or incorrect train behavior.

The rules and method of changing headways (to distribute the extended gap ahead of a delayed train among its leaders or to distribute the reduced gap behind a delayed train among its followers) were formulated and tested using the simulation program. Also the method and rules for offsetting the entire system in time (positive when performance index is bad and negative, or back to normal, in steps when the performance index gets good again) were formulated and tested using this rapid transit system simulation program. Last but not least, rules and actions for hits in the decision table were determined from many simulation runs under various operating conditions. An example of the print-out from a portion of a simulation run is shown in Figure 4.

BART CONTROLS

This simulation method attempts to solve only one of the many problems associated with the design and construction of computer-controlled urban rapid transit systems. It is based on the assumption that the system has been designed so that the computer is used only for monitoring what the system is doing and for controlling the system to optimize passenger satisfaction and convenience. An independent block signal control system is still needed to prevent trains from getting too close to each other, as is a redundant local controller at passenger stations.

The control strategy logic needed to maintain the current operating schedule under normal operation with small random variations can be completely tested via simulation for automatic operation under computer control. But because of the large number of combinations of abnormal conditions and their random delays that can occur, the testing of the decision table logic can never be completed. Hopefully a representative sample of the many possible combinations of events that can occur will be used in testing the decision table logic. It is a physical impossibility to test the logic with all combinations of what could happen on the system.

The rapid transit system simulation program proved to be a very valuable and practically indispensable tool in analyzing a large urban rapid transit system and formulating the control strategy logic. Even for the so-called simple adjusting of performance level and changing dwell time, pitfalls were encountered that would have otherwise shown up much later when changes would have been difficult or even impossible. It is felt that for urban rapid transit systems of any magnitude and complexity, a digital simulation approach should be used to analyze and test even simple control adjustments. Much can be learned and valuable information gained as to how the system will eventually operate.

C&S are service organizations

Operating department views

Q. What understanding, cooperation or support do you expect or desire from your signal and communications departments?

Q. How often and by what means do you keep your signal and communications officers informed of company policy, goals and programs?

Q. What do you think should be the relationship between management and the signal and communications departments?

A. I expect our communications and signal personnel to keep me abreast of new developments that are adaptable to our use in both fields. I also expect them to investigate and thoroughly analyze suggestions for improvements and/or additions to our facilities that are suggested by myself or members of my staff. Also, I expect the signal department to see that our signal systems function properly at a minimum cost to keep the trains moving, and that the communications department supply services not only for operation of the road but also service to other departments in accordance with their needs. This service is to be provided as nearly as possible to maximum efficiency with minimum cost.

Information is provided regarding policy changes as they are made either by letter or by personal briefing. Information regarding goals and programs in which either the communications or signal departments are involved is provided through correspondence and by having our communications and signal officer or his representative sit in on meetings to work out goals and programs in which his department is affected.

I am of the opinion that the relationship we have established is the proper one and that is for the two departments, communications and signal, to report to a single head who in turn is on my staff. Insofar as the signal department is concerned, their functions are directly involved in the operation of the railroad and as such should report in the manner we have established.

The communications department is also directly involved in the operation of the railroad and provides com-

C&S department views

Q. What understanding, cooperation or support do you expect or desire from your management?

Q. How often and by what means do you keep your management informed of your department's policy, goals and programs for the railroad?

Q. What do you think the relationship should be between your department and management?

A. In order for the department of signals and communications to properly fulfill its mission, it is essential that cooperation and support be obtained from all levels of management. Over the years, members of this department have worked closely with other departments and at the present time, we have a generally good working relationship with all of them.

Our management is kept informed of our department's policy, goal and programs by a variety of means. I personally make it a point to confer with our vice-president, chief engineer at least once and often twice a day in order to keep him advised and to permit an expression of his views to me. I similarly work with the general manager, director of management services, the chief mechanical officer, superintendent of transportation, and others on an informal person-to-person basis in order to maintain inter-department coordination. From time to time on special projects, reports are prepared and circulated to those concerned. Generally speaking, we endeavor to keep a steady upward flow of communication to the higher levels of management and to maintain a lateral exchange of information with other departments operating in the same reporting level in the railroad organization.

The department of signals and communications must have a close relationship with other sectors of management. Signals works intimately with engineering and provides services to the operating department. Communications supports operating department activities and is of great importance in traffic department functions and in the last analysis, provides a service to each and every employee on the railroad. The department is unique in this respect in that it probably deals with a wider range of cus-

munication facilities that have to do with train movement. They also provide facilities for the information services department and telephone and telegraph facilities for all other departments of the railroad. As a services department, they properly belong in the operating category. This is particularly true since the predominance of their work and the facilities which are provided are used in connection with the operation of the railroad: for example, VHF radio on locomotives and cars and for point-to-train communication as well as on automobiles and trucks for maintenance, land line facilities for dispatching of trains, and handling of message traffic, as well as transmission of printed message matter. Our direct distance dialing telephone system provides service for all departments and by means of telegraph carrier channels on a limited number of telephone channels, service is provided for the information services department in the collection and transmission of data.

L. Cena, Vice-President, Operations, Atchison, Topeka & Santa Fe

A. We expect and receive the fullest cooperation of these departments whose functions also include the responsibility of keeping management appraised of the latest devices, systems and developments which may improve the operation of the railway.

Information and direction in regard to company policy, goals and programs is disseminated to management of the applicable departments as policies, goals and programs are authorized. This is accomplished in many ways—through meetings, various employee publications, including "Management News" which is published every week to 10 days and is specifically directed to senior and middle management. The signal department plays an important role in the development of medium and long term plans for the company and, therefore, is instrumental in developing recommended policies, goals and programs for the company.

Signals and communications are vital to the success of any railroad and the senior officers of these departments are part of the management team. It is essential that there be the utmost in cooperation at all stages in formulating policies, setting goals and implementing programs.

J. H. Spicer, Assistant Vice-President, Transportation & Maintenance, Canadian National

A. We expect and receive complete cooperation from supervisory personnel in our signal and communications departments. This involves all phases of operation, construction and maintenance of facilities in these departments.

We are in constant contact with the heads of these departments regarding company policy, changes in operation, safety provisions and control of expenditures. We also encourage modernization and improvements to the systems for improved service and more economical operation.

The relationship between management and signal and communications should be very close since these departments play a vital role in the overall operation of the railroad to provide fast, efficient, safe and economical service to our customers.

W. J. Holtman, Executive Vice-President and General Manager, Denver & Rio Grande Western

A. Define in layman's language, signal and communication requirements, goals and present activities. Signal and communications officers should keep informed of changing

(Please turn to page 42)

tomers within the corporate organization than any similar group. This wide range of activities makes the work of the department interesting and brings members of the department in contact with a broad spectrum of the railroad management.

It has been my observation that it is not sufficient for a signal and communication department to merely do its job well. It must additionally point out to those it serves the dimension and magnitude of the problems which it must face and overcome. There is a tendency on the part of the users to take the services for granted at times and to underestimate the technical difficulties incidental to the creation, maintenance and operation of the facilities and services which the department provides.

Signal and communication departments have a difficult problem in that while they produce essential services for railroad management, they are not revenue producers. Nevertheless, they are indispensable to railroad operation.

Donald L. Wylie, Assistant Chief Engineer, Signals & Communications, Milwaukee Road

A. I expect to receive from the management all of the understanding, cooperation and support necessary to achieve the policy, goals and programs of the railroad. By that, I mean I do not always get my way, but after discussing the problems and goals with the various responsible people, a decision is always worked out which we feel to be in the best interest of the railroad.

I try as often as necessary to keep my management informed of our department policy, goals and programs. I do this by whatever means is necessary, such as by personal contact and correspondence.

The relationship between our department and management should be such that our department serves the railroad in the most efficient manner necessary to provide the required signaling and communications for a totally efficient transportation company. In our department, we enjoy the very close relationship with other departments on the railroad, such as maintenance of way, operating, law and personnel.

James I. Adams, General Superintendent Communications & Signals, Louisville & Nashville

A. Communications is strictly a non-revenue service department on the majority of the nation's railroads. The prime objective of a communication department should be to provide adequate service at minimum cost. Most managements recognize the service-cost relationship for communication requirements if the pertinent facts are properly presented to them. Understanding, cooperation and full support can, and should be expected if management has confidence in the ability and integrity of the department.

A communication department policies, goals and programs are, for the most part, dictated by company policies in the economic, labor and human relations fields. Communication requirements for operations, sales, maintenance of plant and equipment, as well as accounting and data services, also enter into system plans and programs for communication service expansions. In each distinct area, the department heads must be kept currently informed, in detail, of progress being made with communication services in their respective areas. Bi-monthly, management should be informed in a concise memorandum of the overall progress being made to satisfy the individual departments requirements, and implement system objectives.

The very nature of communications makes it essential that no barriers exist between communications and other

(Please turn to page 42)

Data Modem Characteristics

Manufacturer	Sangamo Electric	Sangamo Electric
Model	T201B1, B2	T201B3, B4
Transmit and/or receive	Transmit & receive	Transmit & receive
Full and/or Half Duplex	Full or half duplex	Full or half duplex
Dial up or Private Line Application	Private line	Private line
Turn around time (HDX)	—	—
Automatic answer capability	Internal	804A Control Unit
Type modulation	PM	PM
Operating Frequencies	1800 Hz carrier	1800 Hz carrier
Clock, internal or external	B1 Internal	B3 Internal
	B2 External	B4 External
Loop back testing feature	Yes, optional	Yes, optional
Error rate	—	—
Error detection and/or correction	No	No
EIA RS-232-B interface	RS-232-B	RS-232-B
Bit or character rate	2400 bits/sec	2400 bits/sec
Serial or parallel transmission	Serial	Serial
Impedance to line, ohms	600 or 900	600 or 900
Impedance to data equipment, ohms	RS-232-B	RS-232-B
Voltages to and from data equipment	—	—
Frequency stability	—	—
Level stability	—	—
Output levels to line, dbm	—	—
Input levels, from line, dbm	—	—
Line requirements, frequency response	3002 with C2 conditioning	3002 with C2 conditioning
Line requirements, envelope delay	ditto	ditto
Line requirements, impedance	ditto	ditto
Line requirements, signal to steady noise	ditto	ditto
Line requirements, signal to impulse noise	ditto	ditto
Method of operation	2 or 4 wire	2 or 4 wire
Temperature and humidity limits	—	—
Power requirements	117 or 235 volts	117 or 235 volts
	47-63 Hz	47-63 Hz
Dimensions and weight	—	—
Digital or analog	Digital	Digital

(Continued from page 12)

C. W. Compher
Gen Ry Signal

John B. Griffith
S&C Div. Wabco

● T. A. EDISON INDUSTRIES: **John J. Swiss,** service engineer, has been appointed field engineer with headquarters in Chicago. Mr. Swiss was born in Jersey City, N.J. on December 27. 1932. He joined the signal department of Erie-Lackawanna in 1956 and advanced to the position of leading signal maintainer. In 1966, he joined Edison as a service engineer in the Primary Battery Division.

● GENERAL RAILWAY SIGNAL CO.: **Clarence W. Compher,** sales engineer at Chicago, has been appointed resident representative in the GRS Atlanta, Ga. sales office. A graduate of Rochester Institute of Technology, Mr. Compher started at GRS in field signal construction and later was appointed application engineer prior to becoming a sales engineer in the Chicago office.

Robert B. Hio, formerly signal foreman, Boston & Maine, has been appointed sales engineer in the New York office. Mr. Hio joined B&M in 1948 as an assistant signalman and later was promoted to signal maintainer, leading signalman and signal testman, prior to becoming signal foreman.

● WESTINGHOUSE AIR BRAKE CO.: **John B. Griffith,** sales engineer, Eastern Regional Office in Philadelphia, has been transferred to the Signal & Communications Division office in Atlanta, Ga. Mr. Griffith joined Illinois Central in 1944 and, subsequently, became an application engineer in the Union Switch & Signal Division of WABCO in 1955. In 1962, he was appointed sales engineer in New York and four years later transferred to the Philadelphia office.

Obituary

● GEORGE K. THOMAS, retired signal engineer system, Santa Fe Railway, died April 21 at Topeka. Mr. Thomas, born at Castletownroche, County Cork, Ireland, on August 23, 1887, entered Santa Fe service as a signalman on the Eastern Lines January 18, 1909. He devoted his entire career to the signal department, serving successively as signal maintainer, division signal foreman and chief signal draftsman. On June 16, 1941, he became assistant signal engineer system, and was promoted to signal engineer system May 1, 1934.

Mr. Thomas retired from Santa Fe service on August 31, 1957.

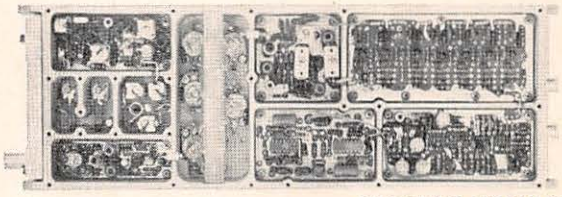
Five channels (960 MHz) $3,200*

For the 790 to 960-MHz band, Granger Associates introduces a new solid state microwave transmitter/receiver terminal. The G/A Model 6010 provides five full channels plus optional order wire in a small, rugged package. The complete terminal including power supply takes just 5¼ inches in standard 19-inch rack.

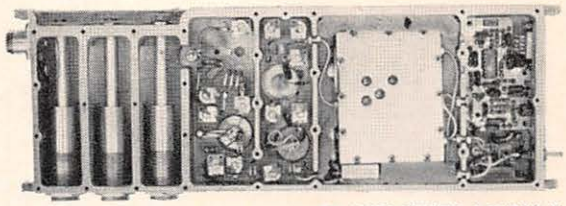
The new Granger microwave terminals are made for telephone circuits, railroad work, unattended repeater stations, supervisory control and telemetering.

The January 1, 1970 FCC deadline is coming ... let us help you be ready.

*price for radio terminal; multiplex equipment additional



RECEIVER MODULE



TRANSMITTER MODULE

Granger Associates / GRANGER COMMUNICATION SYSTEMS DIVISION

1601 CALIFORNIA AVE., PALO ALTO, CALIFORNIA 94304

Circle 15 on reader service card

Operating department views

(Continued from page 39)

trends in the art of railway signaling and communications and bring such to the attention of management. Signaling and communications officers should recommend appropriate tests for analyzing new equipment and materials, maintain long range plans for upgrading signal and communications systems, afford technical guidance for maintenance and construction forces, establish maintenance standards compatible with FRA regulations and within economic guidelines.

Signal and communications officers are included in the annual program planning for the succeeding year. Company long range plans and strategy are discussed with them at frequent intervals (no less than every three months).

There should be a free exchange of ideas with signal and communications officers furnishing recommendations and guidelines to management in their respective areas. When management has reached a decision and announced a strategy and goals, then the signal and communication officers should concentrate their efforts in support of such goals.

J. L. Robson, Vice-President Operating Department, Great Northern

A. I expect the signal and communications departments to be progressive in thinking and aggressive in action. They must be alert to know and understand new technology. An elment of their staff must be dedicated to application of modern equipment to aid management in better control and safety of operations as well as reduction of costs. They must not assume a position of support, but constantly develop new methods and press management for approval. The signal and communication departments should be organized to respond in short time frame, to the environments resulting from administrative and/or operational change.

Monthly briefing sessions, update signal and communication officers as to company policy, goals and programs. Operational and administrative changes are projected with signal and communication officers participating in the planning and implementation.

The signal and communication departments should be utilized by management in the sense of a line organization. They must be aligned so that their activities will not be limited due to functioning through layers of staff organization. Such alignment will permit them to participate in reaching company goals and be responsive to the needs of the company before the demand for communication and signals becomes evident to others in the organization.

Vice-President Operations (Name Withheld By Request)

A. The signal and communications department is an integral part of the organization of our company, and as such we not only expect but receive thorough understanding, cooperation and support from it in all phases of our company's operations, especially those in which it has a direct interest or responsibility. Much of our railroad is already equipped with traffic control and we have a continuing program to expand this type of signaling. Likewise, much of our railroad is equipped with central radio communications, and we also have a continuing program for the expansion of these facilities. Voice, teletype and the more sophisticated data processing communications come under this department, which facilities are constantly being ex-

(Please turn to page 44)

C&S department views

(Continued from page 39)

departments of the ultimate in satisfactory results are to be obtained. Enlightened management is cognizant of this fact and encourages complete intercourse between departments, bypassing immediate administrative control in most instances. While some administrative policy problems can arise through abandonment of the true and firm chain-of-command concept. proper liaison at all times with those concerned can minimize its effects.

Paul A. Flanagan, Superintendent of Communications, Chesapeake & Ohio/Baltimore & Ohio

A. We often hear these comments: "I can't expect understanding, cooperation or the support of management when I approach them about a particular need or requirement insofar as spending money for the improvement of communication facilities is concerned." First of all, the word "expect" is a key word. No one has the right to expect anything along this line. We must earn the understanding, cooperation and support of our managements so that when our desires are made known to them, then management will give them fair consideration. This is not necessarily the easy road to follow in obtaining management support, but it certainly is the one that pays the greatest dividends.

In order to accomplish this, management must be kept constantly informed of a department's policy, goals and programs—not only those of today, but management must be advised years in advance of what the communications requirements may be. For example, we have all known for years that the railroad industry was rapidly moving in the direction of computer usage and all the many accomplishments which data facilties would provide. When this was first known, it was our responsibility as communications people at that time to begin making cost studies as to the feasibility, return on investment, etc., associated with an up-to-date communications system which could provide management with the proper facilities for feeding these computers. It is our responsibility as communications people to keep our managements informed well in advance of what other future requirements might be.

It follows that if we constantly keep our management alert to new developments and means of providing the right kind of communications at the right time, that the relationship between the communications department and management will gradually become a close one. Management can rely on the judgment of the communications people as to when and how such facilities can best be provided. Communications people too often operate under the assumption that when management has a problem involving communications, they will bring it up and then the communications people can begin their feasibility studies or propose solutions. This method of operation, rather than constantly keeping management informed, is an operation in reverse and will certainly not rasise the prestige of the communications people in the eyes of management.

Superintendent of Communications (Name Withheld By Request)

A. On the Frisco, the communications and signals department enjoys excellent cooperation and support, not only from higher management but from other departments as well.

We keep our management informed of our goals and programs by reports, studies, requests, meetings and informal conversation.

(Please turn to page 44)

View from the Crossarm

• *Management: Theory and Practice.* In this second edition, author Ernest Dale incorporates many new developments in the field of management with particular emphasis on the use of computers and management science (operations research). In the chapter on the computer itself—what it can and cannot do at present and what it is likely to do in the future—Dr. Dale explains in clear, nontechnical language such concepts as time-sharing, teleprocessing and the use of the light pen. The second chapter on computers, dealing with its effect on management, includes material drawn from an original survey of prominent users of third-generation computers conducted by the author, as well as the findings of other surveys.

The material dealing with typical operations research problems and their solutions is lucidly presented. A number of various OR techniques are illustrated by problems that can be solved by ordinary arithmetical or algebraic procedures—and more problems, together with their solutions are given in an appendix to the chapter.

In addition to providing a wealth of information on new developments in management, Dr. Dale provides in-depth discussion of the functions of management—planning, organizing, staffing, directing, controlling, innovation and representation—and a comprehensive treatment of decision making.

"The manager of the future will have to become much more articulate in making the position of his industry clear, both to government agencies and to members of the general public.

"Labor unions are not likely to disappear, but may become less important as the white-collar labor force continues to grow as a percentage of the total labor force.

"Increased government regulation of unions is also quite likely in the future, with perhaps greater government control of the whole process of collective bargaining.

"Managers of the future will need to be, and will be, better educated than those of today, particularly in mathematics. While some of the decisions they now make may be routinized through the use of computers, human decision making will still be necessary," Dr. Dale concludes.

Management: Theory and Practice, Second Edition, by Ernest Dale, PhD., Wharton School of Finance and Commerce, University of Pennsylvania, 768 pages, McGraw-Hill Book Co. Price: $10.50.

SALES ENGINEER

Chicago based railway supply company has opening for sales engineer. Prefer man with some experience in CTC and crossing protection work. Sales experience preferred, but not required. SEND RESUME STATING SALARY REQUIREMENT TO: *Box 1000, Railway Signaling & Communications, 29 East Madison St., Chicago, Ill. 60602*

ELECTRONICS ENGINEER

For permanent position in the Chief Engineer's Office, Montreal. Position will involve investigation and evaluation of new equipment; system feasibility studies; establishing installation and maintenance procedures related to the design and use of various types of electronic remote control and automation systems. Such systems may include carrier, telemetry, radio, digital and relay logic, process control computers, radar, etc.

The successful applicant will have 3-5 years experience in some of these types of industrial electronics. Railway experience will be an asset.

Salary commensurate with experience and qualifications.

Please apply in writing giving full particulars of experience and qualifications to Supervisor of Employment, 910 Peel Street, Montreal, Quebec.

CANADIAN PACIFIC

Now is the time to sell your obsolete line wire!

When plans call for going underground, a big part of the problem is up in the air. Diversified Dismantling Corporation, with its miles of experience in removing and salvaging communication wire and poles over every type of terrain and through congested neighborhoods, can take care of the problem for you and increase your salvage revenue.

Write, wire or call collect:

Diversified Dismantling Corporation
Subsidiary of Diversified Metals Corporation
123 Byassee Drive
Hazelwood, Missouri 63042
Telephone 314 731-3060

Western D.M.C.
Cucamonga, California
Eastern D.M.C.
Tamaqua, Pennsylvania
Liberty Smelting Works Ltd.,
Montreal, Quebec, Canada

Circle 16 on reader service card

Operating department views

(Continued from page 42)

panded and which facilities require a high standard of maintenance in order to insure the dependable flow of data through such circuits. We place considerable emphasis on the importance of all facets of the responsibility of the signal and communications department, since its effectiveness as well as its efficiency is vital to the success of our company.

The two top officers in the signal and communications department are required to attend each of the staff conferences held by the president of our company, at which they are kept abreast of the goals and programs that our chief executive has in mind and are also informed firsthand of the policies of our management. Such staff conferences conducted by the president are held at intervals of approximately every 60 to 90 days.

In an endeavor to have the signal and communications department become more of an integral part of our operations, we have organized as a section of the operating department a transportation and maintenance department under the direct control of a vice-president. The transportation, maintenance of equipment, engineering and maintenance of way, and signal and communications departments all report to this officer.

Vice-President Operations (Name Withheld By Request)

A. I expect and receive full cooperation and support from my signal and communications departments in all operating matters where signals and communications are involved.

My signal and communications officers are kept currently informed of company policy, goals and programs through their superior officers by means of directives and staff meetings.

The relationship between management and the signal and communications departments should be so oriented that the communications and signal officers can properly assume their overall responsibility for proper engineering design, construction and maintenance of communication and signal facilities.

R. G. Flannery, Vice-President—Operation, Penn Central

A The signal and communication departments are two of several departments which report to me and, needless to say, I expect complete cooperation and support and would take the necessary steps to see that I get it.

J. C. Kenefick, Vice-President—Operation, Union Pacific

C&S department views

(Continued from page 42)

We feel that the best possible relationship between the C&S department and management should be one that works toward the best interest of the company as a whole.

To a great extent, the relationship of any department with its higher management depends upon the reputation which that department has been able to build. A history of reliable and accurate performance inspires confidence and a willingness to consider requests and proposals. It is the responsibility of the department head to understand his company's overall problems and goals, and to insure that his department's efforts contribute to the company's progress and growth.

Oscar H. Summers, General Superintendent Communications & Signals, St. Louis-San Francisco.

ANY WIRE, ANYWHERE.

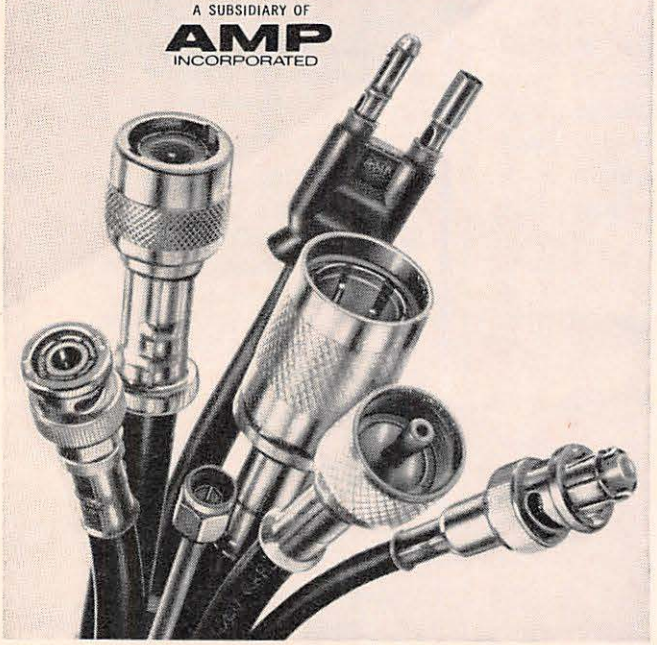
Coaxial and RF cable connectors for any place you need them . . . and direct sales and assistance anywhere in the U.S.A. Over 30,000 other wire connecting products from #26 AWG to 1000 MCM. Talk to us about your connecting problem or write for free Terminal and Connector Handbook. American Pamcor, Inc., Valley Forge, Pa. 19481

AMERICAN PAMCOR

A SUBSIDIARY OF

AMP

INCORPORATED



Circle 17 on reader service card

WANTED: CIRCUIT ENGINEER

Salary to $15,000

B.S. degree and electrical technology or equivalent. Must have minimum 5 years experience in railroad signal circuit design, construction and/or maintenance.

Excellent benefits.

Apply in person or send resume to Manager of Recruitment

Long Island Rail Road

Jamaica Station, Jamaica, N.Y. 11435

An Equal Opportunity Employer

Advertisers' Index

American Pamcor, Inc. 44

Cable Communication Systems, Inc. 6
C & D Batteries Division 8
Copperweld Steel Company 9

Diversified Dismantling Corp. 43

General Railway Signal Co. 7
Gould National Batteries, Inc. 13
Graybar Electric Company 14-15
Granger Associates 41

Harmon Electronics, Inc. 4
Hayes Track Appliance Co. 45

Jeumont Mors Saxby 45

Kerite Company, The ..... FC

Landcom Division of U.S. Underseas Cable Corp. 3
Lenkurt Electric Company 11

RACO ..... IFC

Servo Corporation of America 24-25
Stromberg-Carlson ..... IBC

Transcontrol Corporation 10

Western-Cullen Division ..... BC

Hand-thrown or remote-controlled

Hayes ALL-STEEL DERAILS

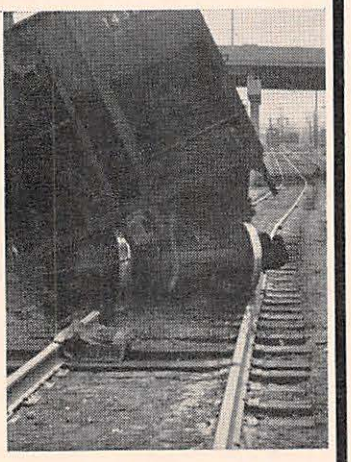
physically protect the main line

Derails or signals? Each has its place: signals are obeyed by men; Hayes Derails are obeyed by equipment.

When signals are not involved, the Hayes Derail alone is competent to keep the main track clear.

In modern signal systems, the Hayes Sliding Derail with DeLectric® Operator under remote control provides complete protection.

The "calculated risk" of omitting derails may be costly. Hayes Derail protection is inexpensive.



© 1968 H.T.A. Co.

Free leatherette ring-binder catalog of world's most-specified derails, bumping posts and wheel stops (including periodic supplement sheets). Write on letterhead.

Track safety devices that WORK at the job.

Hayes Track Appliance Co.

RICHMOND, INDIANA 47374

Circle 18 on reader service card

GROUPEMENT DE SIGNALISATION FERROVIAIRE

J-M-S

194, AVENUE PRESIDENT WILSON
93 - LA PLAINE St-DENIS
Tel. 243.27.63 (PARIS, FRANCE)

JEUMONT-SCHNEIDER MORS SAXBY

Automatic block system
C.T.C. and remote control
Tokenless block
"All relay" interlockings
Points and signal machines
Safety relays
Electronic track circuits
Level crossing equipment
Automation in marshalling yards
Retarders
Mechanical
electromechanical
and electronic operation of
all safety and
signalling equipment.

publiscope

Circle 19 on reader service card

Product News

Presence Detector

Switch protection with electronic presence detectors can now be carried out with increased fail-safe reliability using the new RCA PD-2 railroad car presence detector. Other user benefits include installation versatility, simplified tuning and maintenance, and the high operational reliability derived from the solid-state circuit design.

The new PD-2 utilizes the rails as the detection loop avoiding the need for above ground cables or insulated joints. Additional installation flexibility stems from a sensing loop size range of 25 to 250 ft.

Three basic units make up the new RCA PD-2 system: an inductance loop, a power supply, and a detection module. The loop is connected via coaxial cable to the detector and power supply mounted in an enclosure remotely located up to 1000 ft away. Systems are available for 110-volt AC or 10-volt DC operation. *Radio Corp. of America. Circle 101 on Reader Service Card.*

Air Cell Battery

A new line of Ucar air-depolarized primary batteries can deliver more power for longer periods of time from the same size case. The new battery was designed principally as a reliable source of power for signal applications in the railroad industry and communications stand-by power. The new Ucar Air Cell battery has about double the instantaneous power capabilities, and power densities as much as 65% greater than other air-depolarized batteries.

A new electroyte of micro-milled lime provides a flatter discharge curve, and permits the battery to operate at lower temperatures than other batteries. The new line consists of six Ucar Air Cell batteries with ratings: ranging from 1.25 to 3.75 volts, capacity from 1,000 a.h. to 3,000 a.h. and maximum continuous drain from 1.25 amp to 3.75 amp.

Ucar Air Cell batteries are shipped either already activated or with the liquid electrolyte in sealed, polyethylene bottles, according to user convenience. This eliminates fluctuations in ampere-hour capacity caused by variations in either the purity or quantity of water added in field activation. Further service reliability is provided by a design that combines anode, cathode, and cover in a strong, durable unit housed in a rugged polyethylene outercase with integral carrying handle. The entire unit is shock resistant, weather stable, strong, and light in weight. *Carbon Products Div., Union Carbide Corp., Circle 102 on Reader Service Card.*

Cable Fitting

The USF-2 "Air-Tap" fitting increases reliability and reduces costs. The USF-2 is a solderless fitting used in lieu of costly flanges, adapters, lead plates, etc., as a means of effecting a reliable air tap through any size or type of cable sheath. The fitting is threaded to accommodate standard F valves, tees, elbows, etc., making it ideally suited for pressure reading locations, contactor placement, by-pass arrangements, and many other applications. The improvements consist of a plastic tube insert for positive alignment of the fitting over a ⅜" drilled hole, and the addition of a neoprene gasket for consistent leak-proof application by a simple tape-on method. *Rezolin Inc., Circle 103 on Reader Service Card.*

● FREQUENCY CALIBRATOR is described in brochure TIC3455. The 4-page brochure describes this new solid state device (S1315A) for calibration purposes that generates a spectrum of precise frequencies from 100 kHz to 500 MHz covering mobile and aircraft bands. Raw crystals and other fundamental frequency devices can also be checked with this unit. *Motorola Communications & Electronics Inc. Circle 104 on Reader Service Card.*

● CARRIER: A new 12-page brochure, T-2123, describes the pulse-code modulation carrier system (T-1) that provides 24 telephone circuits over two cable pairs for extended area service and toll connecting trunks. These voice channels may be used in any combination for voice and data traffic without compromise of signal quality or uniformity of any channel in the system. *Stromberg-Carlson Corp. Circle 105 on Reader Service Card.*

Diode Tester

A new, low-cost tester for SCR's, Triacs, and diode/rectifiers is intended for laboratory and shop applications. The ST-100 is a limit tester that provides go, no-go readout. Any device can be tested, providing it has a leakage current of 10 milliamperes or less at rated blocking voltage, a blocking voltage rating of 20 volts to 500 volts, a conduction current rating of 20 ma or more, and a gate trigger current requirement of less than 100 ma (for SCR's and Triacs). Most devices with conduction current ratings up to 35 amp are within these parameters, and the ST-100 Tester can also be used to evaluate devices with higher current ratings.

Blocking voltage can be applied in either forward or reverse direction. Gate trigger tests on Triacs and SCR's are performed by applying gate currents to a value sufficient to fire the device, with a maximum of 100 ma.

The tester is completely self-contained, portable, operates on 110 volt AC, checks rated voltages to 500 volts, and is simple to operate. Housed in a high-impact-resistant plastic case with etched indices on a brushed aluminum control panel, the compact unit measures only 7⅜" high and 3" deep and 8⅜" long. *Alfred-Thomas Controls, Inc., Circle 106 on Reader Service Card.*

● CHART RECORDERS: A new six-page brochure L-1001A gives complete details on model 2750 precision strip chart recorders for long-term recordings. The recorders described have an accuracy of ±1.5% of the full scale value and also provide continuous visual readout. Interchangeable gearboxes provide dual speed combinations from 20/120 mm per hour to 600/3600 mm per hour. The recorders require less panel space than a 4½" meter when mounted, or they are portable with an optional carrying handle. The illustrated brochure lists accessories and operating ranges for over 40 AC and DC instruments. It includes a new model with a built-in amplifier which gives 50 megohm input impedance, and can be adjusted for full scale values from 0.4 to 25 millivolts DC. *Simpson Electric Co., Circle 107 on Reader Service Card.*

You can shop by postcard in

Railway Signaling & Communication's Supermarket

HELP YOURSELF . . . to the wide variety of manufacturers' literature shown on the preceding pages. You don't have to write, just circle the numbers on the card below. Then drop the card in the mail (no stamp needed). Railway Signaling & Communications will forward your request to each manufacturer and he'll send you complete data free of charge. So . . . get out your pencil and help yourself.

RAILWAY SIGNALING & COMMUNICATIONS

Reader Service Card 7/69

Circle numbers for more information about products and services.

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
23	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**
45	**46**	**47**	**48**	**49**	**50**	**51**	**101**	**102**	**103**	**104**	**105**	**106**	**107**	**108**	**109**	**110**	**111**	**112**	**113**	**114**	**115**
116	**117**	**118**	**119**	**120**	**121**	**122**	**123**	**124**	**125**	**126**	**127**	**128**	**129**	**130**	**131**	**132**	**133**	**134**	**135**	**136**	**137**
138	**139**	**140**	**141**	**142**	**143**	**144**	**145**	**146**	**147**	**148**	**149**	**150**	**151**	**152**	**153**	**154**	**155**	**156**	**157**	**158**	**159**
160																					

NAME .....

TITLE .....

RAILROAD .....

ADDRESS .....

CITY ..... STATE ..... ZIP # .....

THIS COUPON MUST BE USED ON OR BEFORE SEPTEMBER 30, 1969

Reader Service Card

Help yourself to information about products, literature and supplies in the signaling, controls and communications areas. Fill out the other side of the card below, tear it out and mail. It's your Railway Signaling & Communications shopping guide.

Postage Will be Paid by Addressee

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY MAIL

First Class Permit No. 31775, Chicago, Illinois

RAILWAY SIGNALING & COMMUNICATIONS
29 EAST MADISON STREET
CHICAGO, ILLINOIS 60603

ATTN: R. W. McKNIGHT

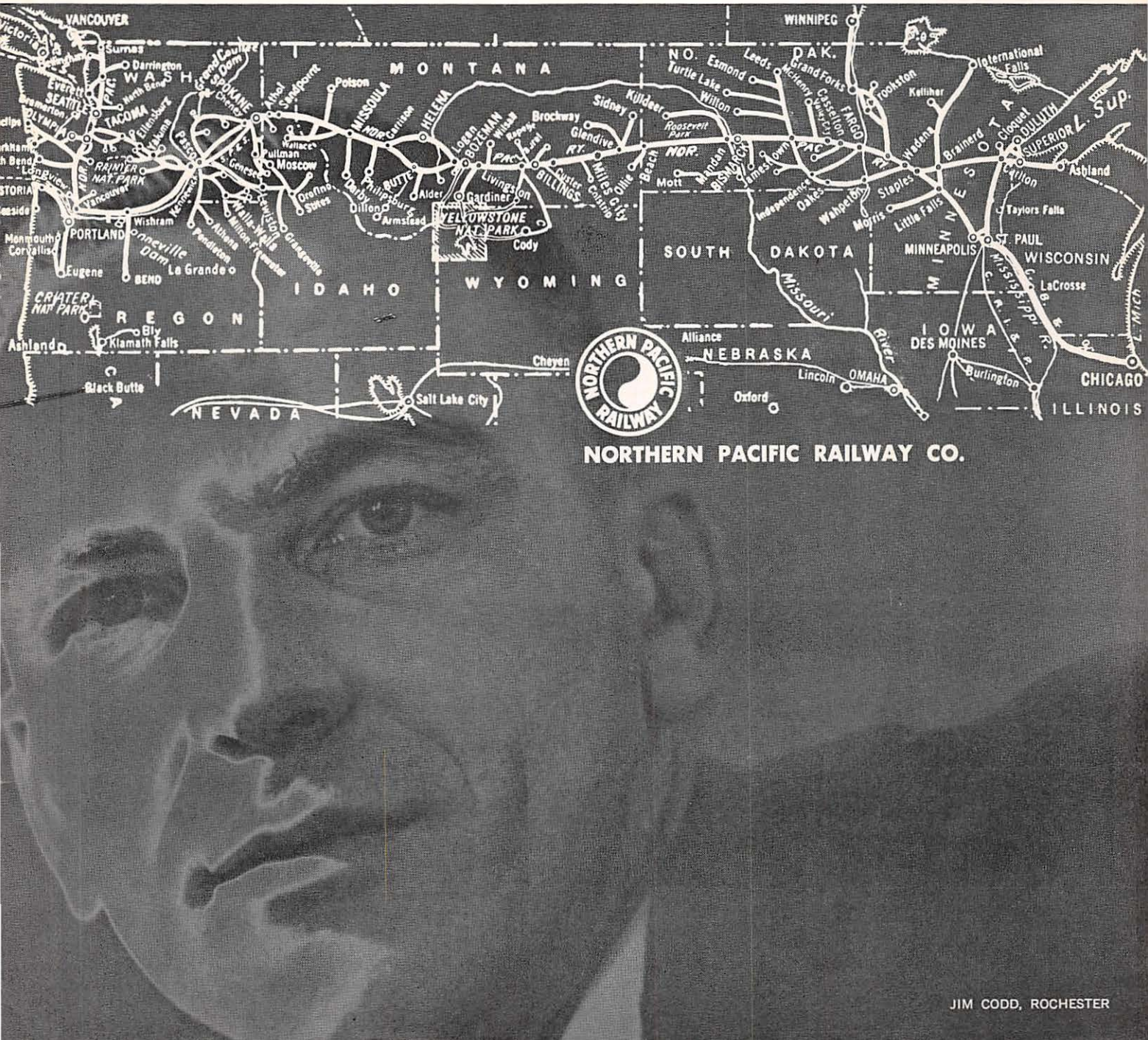
Ask the Stromberg-Carlson Man-on-the-Scene about the last two words in 4-wire switching: common control

With our motorswitch four-wire system working for you, your communications are enhanced with universal numbering and alternate routing. To these common-control benefits add route restriction, priority pre-emption, multifrequency interoffice signaling, one and two digit level operation that allows for 20 or more trunk groups in one switching stage, and common-level operation or pad switching.

Designed expressly for railroad communication switching applications, this 4-wire system switches both voice and data on a no-loss basis between PBX trunk, carrier, microwave, or physical circuits. Capacity of the system is unlimited. And there's virtually no limit to the completeness of the support services that back up the product: system planning and design, application engineering, installation, customer training, leasing/financing, maintenance-service contracts, and follow-through all the way.

Start the ball rolling with a call or letter to the Stromberg-Carlson Man-on-the-Scene at Railroad Division, 100 Carlson Road, Rochester, N. Y. 14603. 716-482-2200.

Stromberg-Carlson
A Subsidiary of General Dynamics

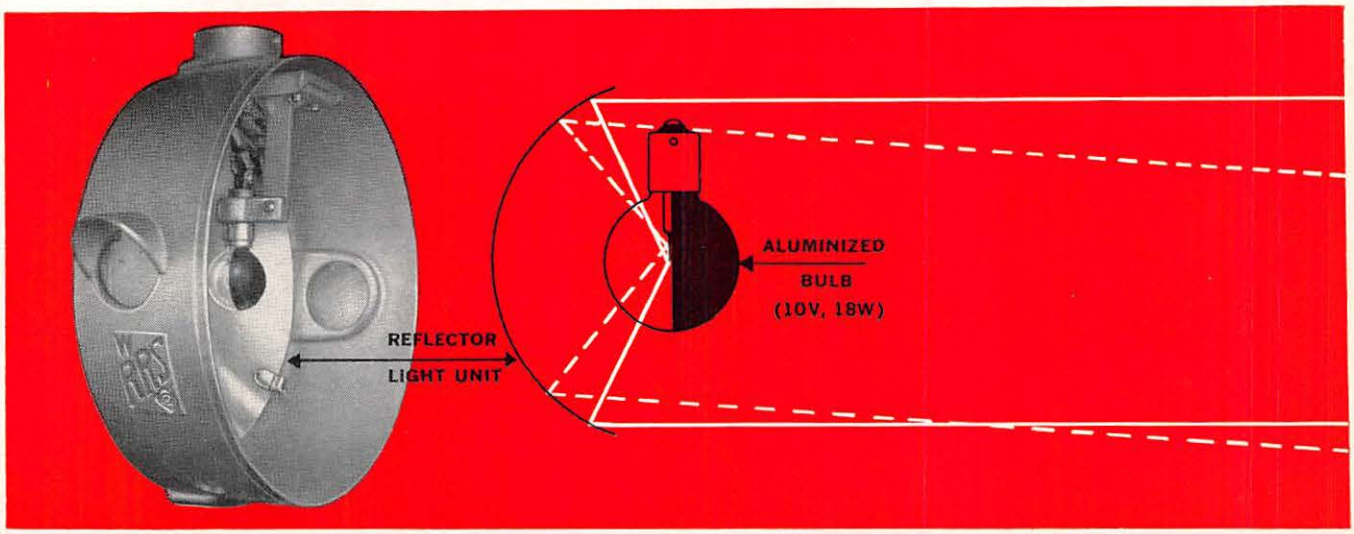


HERE'S THE BRIGHTEST IDEA IN FLASHING-LIGHT SIGNAL BULBS...

WESTERN-CULLEN

Type 90841 (G-12-CC6) REFLECTORIZED BULB

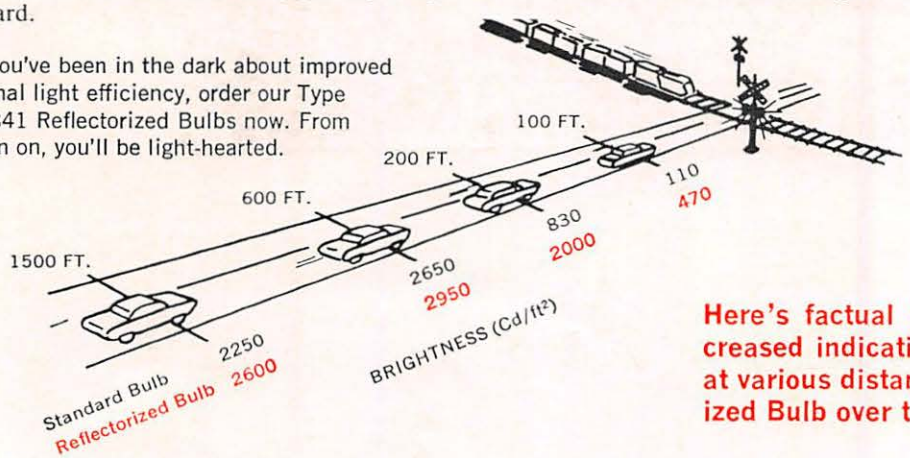
Increases useful light up to 85%



A Simple Design Change Does It. This method of providing improved signal lighting efficiency—with no increase in voltage—is to collect the unused light which is emitted by the filament in the forward direction and reflect it back to the reflector in the flashing-light housing. This redirected concentration of light is then combined with the existing quantity of light and reflected outward.

Basically, the mirrored surface on the envelope of Western's new 90841 Reflectorized Bulb produces a secondary image of the filament just below the true filament. Thereby, the image acts as an additional filament projecting another beam below the axis of the main beam. As a result, these actions serve to increase the useful light in the beam as much as 85%.

If you've been in the dark about improved signal light efficiency, order our Type 90841 Reflectorized Bulbs now. From then on, you'll be light-hearted.



Here's factual proof: Drawing shows increased indication of flashing light signal, at various distances, with use of Reflectorized Bulb over that of Standard Bulb.*

**Based on tests made at the Applied Research Laboratory of the Ford Motor Company. Read article, "Reflectorized bulb improves crossing signal," in November, 1967 issue, Railway Signaling & Communications magazine.*

WESTERN-CULLEN DIVISION
FEDERAL SIGN AND SIGNAL CORPORATION
2700 West 36th Place · Chicago, Illinois 60632
Canada: Woodings Canada, Ltd., 5 Place Ville Marie, Montreal 2, Que.

MEMBER RPI RAILWAY PROGRESS INSTITUTE

5232

Circle 3 on reader service card